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JOURNAL
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CONTRIBUTION TO THE FLORA OF THE NEW HEBRIDES

PLANTS COLLECTED BY S. F. KAJEWSKI IN 1928 AND 1929[1]

A. GUILLAUMIN

With one text figure

RUBIACEAE

Nauclea sp.

Aneityum: Anelgauhat Bay, rain-forest, alt. 60–450 m., no. 954 (coll. *J. P. Wilson*), Sept. 1929 (tree 12 m. high; diam. 0.5 m.; flowers yellow; fruit light brown, non edible).—Vernacular name "Nepec."

Uncaria orientalis Guillaumin, sp. nov.—Fig. 4.

Scandens, ramuli tetragoni angulis obtusatis, glabri vel sparse hirtelli, stipulae ovatae (1–1.3 cm. × 0.5–0.8 cm.), lamina sparsissime hirtella vel glaberrima ad marginem puberula, folia ovato-discoidea (usque ad 11 cm. × 9 cm.), basi truncato-rotundata, apice subito lineari apice rotundato acuminata, membranacea, rigida vel coriacea, glabra vel infra in costa nervisque et praecipue ad nervorum angulos plus minusve hirtella, nervis 6–7-jugis valde prominentibus, nervis parallelis in venis perpendicularibus non prominentibus sed conspicuis, petiolo 1 cm. longo glabro vel sparse hirtello, uncis magnis compressis ad 3 cm. longis, basi 5 mm. latis glabris vel sparse hirtellis, apice bracteis 3 ovatis 3–4 mm. longis, una aliis duplo (2 mm.) latiore ad marginem puberulis, pedunculo medio articulato bracteolatoque dense piloso vel plus minusve glabro, primum horizontali, postea decurvato, deinde (parte superiore et capitulo delapsis) uncato, capitulo fere 3 cm. diam. ebracteolato, calyce 2 mm. longo, ovario aequilongo dense rufo-velutino, lobis rotundatis tubo 3-plo brevioribus, corolla infundibuliformi fere 1 cm. longa, tubo gracile cylindrico extra dense griseo rufo-velutino intus glaberrimo, lobiis rotundatis 2-3 mm. longis extra rufo-velutinis, intus basin versus linea media longitudinali pilosa excepta, glabris, stigmate apice cylindrice dilatato vix exserto.

[1] Continued from Vol. XII, 264 (1931).

Aneityum: Anelgauhat Bay, rain-forest at sea level, no. 910, March 11, 1929 (common vine with sweetly scented, creamy flowers, growing on rain-forest trees). Eromanga: Dillon Bay, common in rain-forest, alt. 400 m., no. 348, June 1, 1928 (vine growing on top of trees; used by natives in case of necessity for making fire by rubbing thick part of vine against a hard wood).—Vernacular name "Tevi-cow."

FIG. 4. UNCARIA ORIENTALIS Guillaumin (× ⅓).

Quite different from the species of New Guinea and the Bismarck Islands which so far have been the most eastern species. It is easy to recognize in these specimens the transformation of the inferior part of the peduncle of the inflorescence into a hook.[1]

Dolicholobium aneityense Guillaumin, sp. nov.

Arbor parva, 7 m. alta, ramis primum setulosis deinde glabrescentibus, foliis ovato-lanceolatis (usque ad 14 cm. × 6 cm.) atro-viridibus membranaceis apice acutis basin versus longe attenuatis, supra primum in costa setulosis deinde glabrescentibus, subtus

[1] Guillaumin in Compt. Rend. Acad. Sci. Paris, 192, p. 1264(1931).

primum costa, nervis marginibusque setulosis, deinde costa excepta glabrescentibus, nervis 14–16-jugis tenuibus subtus prominentibus, venis tenuissimis, petiolo gracili circa 2 cm. longo setuloso stipulis ellipticis apice rotundatis fere 2 cm. longis setulosis cito caducis; inflorescentia axillaris, cymosa, 4–5 cm. longa, 3–5-flora, floribus albis, pedunculo dense rufo-setuloso circa 1.5 cm. longo, calyx membranaceus, obconicus, 0.5 cm. longus, margine undulatus setulosusque, extra glaber, intus reticulose nervosus et basin versus appresse pilosus, corolla 3.5 cm. longa, tubo gracili cylindrico extra appresse setuloso intus glaberrimo, lobis 5 ovato-falcatis apice obtusis circa 6–7 mm. latis aequilongis, extra marginem versus sparse setulosis, antherae 5, sessiles, ad tubi apicem insertae, lineares, 2.5 mm. longae, apice rotundatae, basi parum sagittatae, tubi orem non attingentes, discus tubulosus, basin styli cingens, stylus gracillimus ad apicem valde dilatatus compressusque, antherarum apicem attingens, lobis 2 apice triangularibus, ovarium pedicello indistinctum, 2-loculare, ovulis in quoque loculo ∞.

Aneityum: Anelgauhat Bay, common in rain-forest, alt. 450 m., no. 775, Feb. 18, 1929 (small tree up to 6 m. high, with white flowers and dark green leaves).

Related particularly to *D. graciliflorum* Val. of New Guinea and to *D. oblongifolium* A. Gray of the Fiji Islands.

Badusa occidentalis Guillaumin, sp. nov.

Arbor parva, 10 m. alta, ramis viridibus, foliis ovatis vel ovato-lanceolatis (usque ad 15 cm. × 5 cm.) membranaceis apice breviter obtuseque acuminatis basi cuneatis, nervis 6–8-jugis tenuibus subtus prominulis, venis inconspicuis, petiolo usque ad 2.5 cm. longo, stipulis interpetiolaribus tubulosis breviter mucronatis; inflorescentia corymbosa vel paniculatim corymbosa, foliis fere aequilonga, pedunculo 5–8 cm. longo compresso, bracteis foliaceis ad 2 cm. longis petiolatis, petiolo supra piloso, pedicello 1-1.5 cm. longo gracili apice decurvo, bracteolis triangularibus margine minute erosis supra pilosis, floribus niveis formosissimis, calyx clavatus, apice tubuloso-cupulatus, dentibus 5 minimis margine suberosis, intus velutinus, corolla tubulosa, tubo 5–6 mm. longo, extra glaber, intus medio leviter puberulo lobis 5 recurvis elliptice linearibus apice rotundatis, medio supra longitudinaliter costatis tubo aequilongis, stamina 5, 1.5 cm. longa, filamentis ima basi corollae insertis et tubum brevem formantibus, parte libera dimidio inferiore hispidis, antheris linearibus basi sagittatis, apice obtusis, discus dentibus 5 minimis obtusis circa styli basin, stylus staminibus aequilongus, apice valde clavatus, integerrimus, ovarium 2-loculare, multiovulatum. Fructus clavatus, 1–1.2 cm. longus, tubo calycino

coronatus, septicide 2-valvis, seminibus valde compressis breviter alatis.

E r o m a n g a : Dillon Bay, common in rain-forest at sea level, no. 393, June 8, 1928 (small tree up to 10 meters, with pretty snow-white flowers).—Vernacular name "Ney in watu."

Only one more species of this genus is known which is restricted to Tonga, while another, *B. philippica* Vidal, non Blanco, remains doubtful.

Oldenlandia Crataeogonum Guillaumin in Lecomte, Not. Syst. III. 160 (1915).

E r o m a n g a : Dillon Bay, common in poor, red soil country, alt. 400 m., no. 352, June 1, 1928. Also in New Caledonia.—Vernacular name "Noo lay yelong."

Mussaenda cylindrocarpa Burck in Ann. Jard. Bot. Buitenzorg, III. 118, t. 17 (1883).

E r o m a n g a : Dillon Bay, common in rain-forest, alt. 400 m., no. 349, June 1, 1928 (small tree about 7 m. high with yellow flowers).—Also New Guinea and Bismarck Islands.—Vernacular name "Tear vess."

Mussaenda frondosa Seemann, Fl. Vit., 123 (1886); non Linnaeus.

A n e i t y u m : Anelgauhat Bay, common on seashore, no. 922, March 17, 1929 (small tree up to 9 m. high with brown fruit when ripe).—Already found in Aneityum.

Identical with Polynesian specimens (Fiji, Tonga, Wallis, Samoa and Solomon Islands), but different from those of New Caledonia and the Bismarck Islands and also from those of the Caroline Islands which Valeton considers as two distinct species. Merrill has suggested that this may be the same plant as *M. philippica* Rich. of the Philippines.

Chomelia (Tarenna) **banksiana** Guillaumin, sp. nov.

Arbor parva, 6 m. alta, ramis cylindraceis, glabris, raro foliatis, folia glaberrima, elliptico-lanceolata, usque ad 19 cm. × 8 cm., papyracea, basi apiceque acute cuneata, costa infra valde prominente, nervis circa 10-jugis subtus prominulis, petiolo glabro supra leviter sulcato 1.5–4 cm. longo, stipulis brevibus (3–5 mm. longis) glabris apice acutis; inflorescentiae latiores, terminales, foliis multo breviores, ramis minutissime adpresseque setulosis, bracteis linearibus setulosis, floribus albis, pedicello minutissime adpresseque setuloso apice bracteola filiformi minute setulosa munito, calyx turbinatus, haud costatus, lobis bene distinctis rotundatis dense ciliolatis, intus glaber, extra basin versus minutis-

sime adpresseque setulosus, 2 mm. longus, corolla tubo cylindrico lobis longiore extra minute adpresseque puberulo intus medio apicemque versus sparse barbato 5 mm. longo, lobis 5 patulis ellipticis apice rotundatis (3.5 mm. × 2 mm.) intus glabris extra ut tubus minutissime adpresseque puberulis, stamina 5, fauce inserta, filamentis brevissimis, antheris lineari-lanceolatis basi breviter sagittatis lobis leviter brevioribus, ovarium 2-loculare, quoque loculo 6-ovulato, stylo subulato 1 cm. longo tubi medio sparse barbato. Fructus globosi, 4 mm. diam.

Banks Group: Vanua Lava, common in rain-forest at sea level, no. 470, July 12, 1928 (small tree up to 6 m. high with white flowers).

Remarkable for the distinct rounded lobes of its calyx and the small acute stipules.

Chomelia sp.

Aneityum: Anelgauhat Bay, common in rain-forest alt. 60 m., no. 744, Feb. 12, 1929 (large tree up to 12 m. with black fruit). Eromanga: Dillon Bay, common in rain-forest, alt. 300 m., no. 290, May 23, 1928 (small tree up to 8 m.).—Vernacular name "Deuv-yourit."

Randia sezitat Guillaumin in Arch. Bot. Mém. III. no. 5, 9 (1930).

Aneityum: Aname, common on seashore along w. coast, alt. 30 m., no. 991 (coll. *J. P. Wilson*) Sept. 1929 (small tree 15 cm. diam. with white flowers and brown fruit).—Also New Caledonia and Loyalty Islands.—Vernacular name "Daramdaram."

Gardenia tannaensis Guillaumin, sp. nov.

Arbor parva, 6 m. alta, foliis lanceolatis (usque ad 28 cm. × 8.5 cm.) apice basique acutis rarius apice rotundatis basi cuneatis, membranaceis, nervis 7–15-jugis, subtus prominentibus, venis numerosis, stipulis lanceolatis vel deltoideis 1 cm. longis basi tubum 0.5 cm. longum formantibus, petiolo 1.5–2 cm. longo, gemmis resinosis, flores solitarii, breviter pedicellati, calyce obconico extra glabro, lobis 5, 1.5 cm. longis falciformibus acutis brevissime puberulis, corollae tubo sepalis aequilongo extra brevissime puberulo, lobis 5 tubo aequilongis.

Tanna: Lenakel, very rare in rain-forest soil, alt. 100 m. no. 33, Feb. 21, 1928 (small tree about 6 m.).

Gardenia sp.

Eromanga: Dillon Bay, common in rain-forest at sea level, no. 362, June 4, 1928 (shrub about 4 m. high with white flowers and with leaves which are used for healing by being placed on wound after being heated and rubbed).—Vernacular name "Neace ya vot."

Gardenia sp.

A n e i t y u m : Anelgauhat Bay, common in rain-forest, alt. 180 m., no. 913, March 17, 1929 (small tree up to 6 m. high, with yellow fruit).

This and the preceding species resemble each other in their falciform calyx-lobes.

Gardenia sp.

B a n k s G r o u p : Vanua Lava, common in rain-forest at sea level, no. 489, July 17, 1928 (small tree up to 8 m. high).

Gardenia sp., praecedenti affinis.

E r o m a n g a : Dillon Bay, common in rain-forest, alt. 300 m., no. 369, June 5, 1928 (large tree up to 20 m. high).—Vernacular name "Nor-rooka."

These different species belong to the group with well developed calyx-lobes, not abundant in New Guinea, but well represented in New Caledonia.

Guettarda speciosa Linneaus, Sp. Pl. 991 (1753).

A n e i t y u m : Anelgauhat Bay, common on seashore, no. 799, Feb. 21, 1929 (tree 9 m. high; flowers white, sweetly scented). E f a t e : Undine Bay, common in rain-forest along sea shore, no. 210, April 25, 1928 (tree up to 20 m.; flowers white to cream). E r o m a n g a : Dillon Bay, common in rain forest along sea shore, no. 363, June 4, 1928 (large tree up to 20 m. high).—Already found in Efate; also in New Caledonia, Australia (Queensland, North Australia), Fiji, Samoa, Cook, Society, Union, Ellice, Gilbert, Marshall, Caroline, Mariana, Solomon, Bismarck and Admiralty Islands, New Guinea and Malaysia.—Vernacular name "Ou-ven-ou-ven."

Guettarda Kajewskii Guillaumin, n. sp.

Arbor mediocris, 5 m. alta, foliis obovatis (usque ad 11 cm. × 6 cm.) atro-viridibus membranaceis basi cuneatis apice breviter obtusissimeque acuminatis, nervis 5–8-jugis valde tenuibus parum conspicuis, venis inconspicuis, petiolo ad 1.5 cm. longo, stipulis lanceolatis acutis 2–3 mm. longis extra adpresse argenteo-puberulis, citissime caducis, inflorescentiae densius cymosae, 1.5–3 cm. longae, pedunculo leviter compresso subglabro, floribus subflavis minutis, bracteis ovato-deltoideis minimis, calyx poculiformis, edentatus, corolla 4–5 mm. longa, tubo cylindrico extra praecipue basin versus argenteo-puberulo, lobis 5 rotundatis 2 minoribus (an semper?), stamina 5, fauce inserta, sessilia, leviter exserta, antheris linearibus 3 mm. longis.

A n e i t y u m : Anelgauhat Bay, common in rain-forest, alt.

30 m., no. 724, Feb. 11, 1929 (medium sized tree up to 12 m.; leaves dark green; corolla cream-colored).

Guettarda sp.

Aneityum: Anelgauhat Bay, common in rain-forest, alt. 210 m., no. 826, Feb. 28, 1929 (medium sized tree up to 9 m. high; wood hard; fruit purple when ripe).

Plectronia odorata (Forst.) Hillebrand, Fl. Hawaii Isl. 175 (1888).

Aneityum: Anelgauhat Bay, common in rain-forest, alt. 30 m., no. 726, Feb. 11, 1928 (tree up to 12 m. high; fruit yellow when ripe). Efate: Undine Bay, common in rain-forest, alt. 30 m., no. 191, April 23, 1928 (tree up to 20 m. high; fruit greenish purple when ripe).—Already found on Tanna; also New Caledonia, Loyalty, Fiji, Tonga, Society and Marquesas Islands.—Vernacular name "Toolepau" (under no. 191).

Plectronia sp. affinis *P. barbata* K. Schum.

Tanna: Mt Tokosh Meru, common in rain-forest, alt. 300 m., no. 170, March 15, 1928 (tree about 20 m. high).

Ixora aneityensis Guillaumin, sp. nov.

Arbor parva, 7 m. alta, ramis sat magnis ut gemmis roseis, foliorum delapsorum cicatricibus valde prominentibus, foliis sessilibus lanceolatis (usque ad 30 cm. × 8.5 cm.) apice attenuatis basi auriculatis rigide membranaceis, costa subtus valde prominente, nervis 13-jugis subtus prominentibus, venis reticulatis subtus prominulis, stipulis fere 7 cm. longis triangularibus carinatis apice 3 mm. longe caudato-acuminatis, inflorescentia terminalis, 7 cm. longa, paniculata, ramis brevissime puberulis, bracteis triangularibus longe caudato-acuminatis vel deficientibus, floribus albo-roseis pedicello 3–8 mm. longo vulgo apice subulate bracteolato brevissime puberulo suffultis, calyx ovatus, extra minute puberulus, 3 mm. longus, lobis 4 acutis brevissimis, corolla ad 2.5 cm. longa, lobis 4 lanceolatis extra subglabris tubo cylindrico extra minute puberulo leviter brevioribus, stamina 4, fauce inserta, filamentis brevibus, antheris acutissime lanceolatis basi sagittatis 6 mm. longis, stylus gracilis, apice fusiformis, antherarum apicem attingens.

Aneityum: Anelgauhat Bay, common in rain-forest, alt. 300 m., no. 851, March 2, 1929 (small tree up to 6 m. high; flowers pink-white, with pink buds and stems).

This approaches especially *I. montana* Schlechter of New Caledonia, but the leaves and the calyx are very different.

Pavetta opulina De Candolle, Prodr. IV. 492 (1830).

Aneityum: Anelgauhat, common in lower ranges, alt. 300 m., no. 969 (coll. *J. P. Wilson*), Sept. 1929 (small tree; flowers small, white; fruit a cluster of brown berries). Efate: Fila Island, Vila, common in rain-forest along sea coast, no. 187, April 14, 1928 (small tree 5 m., flowers white).—Already recorded from Eromanga; also in New Caledonia and Loyalty Islands.—Vernacular name "Natge" (under no. 969).

Pavetta sambucina De Candolle, Prodr. IV. 492 (1830); non *Tarenna sambucina* K. Schum.

Tanna: Lenakel, common in rain-forest soil, alt. 100 m., no. 30, Feb. 21, 1928 (shrub up to 5 m.; flowers white).—Also in Fiji and Society Islands.

These two species, extremely close, seem to me hardly distinct from the var. *tomentosa* Hook. f. of New Guinea and Malaysia.

Coffea arabica Linnaeus, Sp. Pl. 172 (1753).

Eromanga: Dillon Bay, common, growing wild in rain-forest at sea level, no. 368, June 5, 1928 (common shrub gathered to see if any difference takes place when it grows wild).

Morinda citrifolia Linnaeus, Sp. Pl. 176 (1753).

Aneityum: Anelgauhat Bay, common in rain-forest at sea level, no. 709, Feb. 9, 1928 (small tree up to 10 m. high; petals white; fruit cream-colored when ripe, 5.5 cm. long, 4 cm. in diam.). Eromanga: Dillon Bay, common in rain-forest at sea level, no. 260, May 15, 1928 (small tree up to 10 m. high; fruit cream-colored; sap of root used by natives as a red dye for grass skirts).—Already found in Efate; also New Caledonia, Loyalty Islands, Australia (Queensland, North Australia), Fiji, Tonga, Samoa, Cook, Society, Marquesas, Union, Ellice, Marshall, Caroline, Mariana, Hawaii, Solomon, Bismarck and Admiralty Islands, New Guinea and Malaysia.—Vernacular name "Noah-i-rat."

Morinda Forsteri Seemann, Fl. Vit. 129 (1866).

Aneityum: Anelgauhat Bay, common in rain-forest at 30 m., no. 725, Feb. 11, 1929 (vine climbing up the rain-forest trees; fruit dark purple when ripe).—Also New Caledonia, Loyalty, Fiji, Tonga, Samoa, Pitcairn, Gambier and Mariana Islands.

Calycosia Milnei A. Gray in Proc. Am. Acad. IV. 307 (1860).

Aneityum: Anelgauhat Bay, common in rain-forest at 180 m., no. 817, Feb. 28, 1929 (small tree up to 6 m. high; flowers white; fruit orange-colored when ripe, 2 cm. long, 1.5 cm. in diam., slightly flattened at each end). Tanna: Mt. Tokosh Meru, common in rain-forest at 800 m., no. 162, March 15, 1928 (small tree up to 8 m. high; flowers white). Eromanga: Dillon Bay,

common in rain-forest at 400 m., nos. 315 and 315A, May 28, 1928 (small tree up to 7 m. high; flowers white; fruit red).—Already found on Aneityum; also Fiji Islands.—Vernacular name "Ney-in-war-tu."

Calycosia sp.

Eromanga: Dillon Bay, alt. 300 m., rain-forest, common, no. 402, June 8, 1928 (small tree, 10 m. high; fruit red when ripe).—Vernacular name "Nem-pel-ted."

Psychotria aneityensis Guillaumin, sp. nov.

Frutex glaberrimus, 4 m. altus, ramis gracilibus viridibus, foliis glabris lanceolatis (usque ad 10 cm. × 3 cm.) apice acutis basi anguste attenuatis membranaceis, nervis 8–12-jugis tenuissimis, petiolo 1–2 cm. longo, stipulis brevissimis deltoideis apice mucronulatis, inflorescentia axillaris vel pseudo-terminalis, cymose umbellata, 2 cm. longa, pedunculo gracili, floribus subflavis, 3–5-nis, pedicello capillari circa 5 mm. longo, bracteis minutissimis, calyx hypocrateriformis, 1 mm. longus, lobis indistinctis, corolla 2 mm. longa, campanulata, lobis ovatis tubo fere 2-plo brevioribus, stamina inclusa, sub fauce inserta, filamentis brevibus, antheris 0.5 mm. longis linearibus apice truncatis basi leviter sagittatis, discus epigynus, tubulosus, stylus antheras leviter superans, basi gracili, apice dilatato, ramis 2 apice truncatis. Fructus pedicello circa 1 cm. longo suffultus, 6–7 mm. longus, pyrenis longitudinaliter sulcatis.

Aneityum: Anelgauhat Bay, common in rain-forest at 30 m., no. 733, Feb. 11, 1929 (shrub up to 3.5 m. high; flowers cream-colored).

Psychotria nacdado Guillaumin, sp. nov.

Scandens, ramis rubris, foliis glabris ovato-lanceolatis (usque ad 14 cm. × 5 cm.) apice acute acuminatis basi cuneatis membranaceis, nervis circa 9-jugis tenuibus subtus tantum prominulis vel immersis, petiolo 1.5–2 cm. longo, stipulis citissime caducis, axillis puberulis, inflorescentia terminalis, pyramidali-paniculata, usque ad 5 cm. longa et 7 cm. lata, multiflora, floribus albis, pedicello 2–3 mm. longo dense papilloso, calyx campanulatus, 1.5 mm. longus, sparse papillosus, dentibus minutis triangulari-acutis, corolla infundibuliformis, usque ad 7 mm. longa, lobis lanceolatis apice intus leviter uncinatis, tubo extra praecipue basin versus dense papilloso intus dimidio superiore dense barbato, lobis extra sparse papillosis intus glabris, stamina exserta, fauce inserta, filamentis antheris fere 2-plo longioribus, antheris 1 mm. longis linearibus apice basique truncatis, discus epigynus, tubulosus, stylus antheris aequilongus, apice dilatatus 2-fidusque. Fructus nigri.

Aneityum: Anelgauhat Bay, common in lower hills up to 300 m., no. **979** (coll. *J. P. Wilson*), Aug. 1929 (vine covering trees; leaves medium; flowers small white, in clusters; fruit small black berries). Banks Group: Vanua Lava, common in rain-forest at 500 m., no. **485**, July 16, 1928 (vine climbing over rain-forest trees; flowers white).

This species is fairly close to *P. rupicola* Schlechter of New Caledonia.—Vernacular name "Nacdado" (under no. 979).

Psychotria sp.

Banks Group: Vanua Lava, not common in rain-forests up to 100 m., no. **411**, June 5, 1928 (small tree up to 10 m. high).

Psychotria sp.

Aneityum: Anelgauhat Bay, sea level, sea shore, common, no. **926**, March 17, 1929 (small tree, 7 m. high; leaves dark glossy green; fruit 8 mm. long, 6 mm. diam., red when ripe).

COMPOSITAE

Vernonia cinerea (L.) Lesser in Linnaea, IV. 291 (1829).

Eromanga: Dillon Bay, common in rain-forest clearings at 300 m., no. **384**, June 8, 1928 (common weed throughout the Island).—Already found on Aneityum, Erronan, Tanna and Eromanga; also New Guinea, Bismarck, Solomon, Fiji, Samoa, Cook, Marshall, Caroline and Mariana Islands, New Caledonia, Australia (Queensland, North Australia, New South Wales), Moluccas and Malaysia.—Vernacular name "Sow-any-longa."

Ageratum conyzoides Linnaeus, Sp. Pl. 839 (1753).

Eromanga: Dillon Bay, common in cleared rain-forest at 300 m., no. **382**, June 8, 1928 (very common weed throughout the group).—Already found in Aneityum, Erronan and Tanna; also New Caledonia, Australia (Queensland), Norfolk Islands, New Zealand, Fiji, Samoa, Cook, Marquesas, Marshall, Caroline, Bismarck and Solomon Islands, New Guinea, Moluccas and Malaysia.—Vernacular name "Ou lakkidine."

Blumea densiflora De Candolle, Prodr. v. 446 (1836).

Efate: Undine Bay, common in rain-forest at 200 m., no. **215**, April 27, 1928 (about 2 m. high growing in clearings; flowers yellow).—Also New Caledonia, Fiji and Bismarck Islands, New Guinea and Malaysia.

Wedelia aristata Lesser in Linnaea, VI. 160 (1831).

Wedelia biflora De Candolle in Wight, Contrib. Bot. India, 18 (1834).

Efate: Undine Bay, common in rain-forest soil of cocoanut

plantation at sea level, no. **196**, April 24, 1928 (up to 3 m. high; flowers yellow; leaves used by natives to give flavor to fish). Banks Group: Vanua Lava, common in cleared rain-forest land at sea level; no. **460**, July 12, 1928 (up to 2 m. high; flowers bright yellow; a troublesome weed).—Already found on Aneityum, Tanna, Eromanga and Efate; also New Caledonia, Loyalty Islands, Australia (Queensland, New South Wales, North Australia), Norfolk, Fiji, Tonga, Wallis, Samoa, Ellice, Marshall, Caroline, Mariana and Solomon Islands, New Guinea, Malaysia.

GOODENIACEAE

Scaevola cylindrica Schlechter & Krause in Engler, Pflanzenr. IV.–277, p. 129 (1912).

Aneityum: Anelgauhat Bay, common in poor red soil country, no. **911**, March 11, 1929 (bush up to 3 m. high; flowers white, sweetly scented). Eromanga: Dillon Bay, common in red soil of poor bracken country, at 300 m., no. **293**, May 23, 1928 (flowers white).—Also New Caledonia.—Vernacular name "Wibe Wibe" (under no. 293).

Scaevola frutescens (Mill.) Krause in Engler, Pflanzenr. IV.—277, p. 125 (1912).

Aneityum: Anelgauhat Bay, common in rain-forest at sea level, no. **786**, Feb. 19, 1929 (common shrub up to 5 m. high, growing along the sea shore; flowers white; fruit white when ripe, 0.75 cm. long, 1 cm. in diam.).—Already found on Efate; also New Caledonia, Loyalty Islands, Australia (Queensland, North Australia), Fiji, Tonga, Santa Cruz, Samoa, Cook, Society, Paumota, Union, Ellice, Gilbert, Marshall, Caroline, Mariana, Hawaii, Solomon, Bismarck and Admiralty Islands, New Guinea, Malaysia.

VACCINIACEAE

Vaccinium Macgillivrayi Seemann in Jour. Bot. II. 77 (1864).

Aneityum: Anelgauhat Bay, common in poor red soil country at 60 m., no. **701**, Feb. 4, 1929 (shrub up to 4 m. high; petals white, stamens yellow; fruit purple when ripe, eaten by the natives). Eromanga, Dillon Bay, common in poor red soil of bracken country at 300 m., no. **301**, May 24, 1928 (small shrub about 3 m. high; fruit black, 1.25 cm. long, 1 cm. in diam., eaten by the natives).—Already found on Aneityum.—Vernacular name "Autarm-tell" (under no. 301).

EPACRIDACEAE

Leucopogon cymbulae Labillardière, Sert. Austro-Caled. 36, t. 39 (1824).

Aneityum: Anelgauhat Bay, common in rain-forest at 50 m., no. 702, Feb. 4, 1929 (crooked tree up to 10 m. high, growing in gullies; corolla white). Eromanga: Dillon Bay, common in poor red soil of bracken country at 400 m., no. 351, June 1, 1928 (shrub up to 3 m. high; leaves bound to a pole are used as brooms).—Already found on Aneityum; also New Caledonia, Fiji Islands.—Vernacular name "Nom-pul-low" (under no. 351).

MYRSINACEAE

Maesa efatensis Guillaumin in Bull. Soc. Bot. France, LXVI. 272 (1920).

Aneityum: Anelgauhat Bay, common in rain-forest at sea level, no. 792, Feb. 20, 1929 (small tree up to 6 m. high; fruit pink-cream when ripe, 0.5 cm. long, 0.7 cm. in diam.). Tanna: Lenakel, common in heavy rain-forest soil at sea level, no. 9, Feb. 20, 1928 (tree up to 20 m. high, dark green with brown veins underneath).—Already found on Efate.

Rapanea modesta Mez in Engler, Pflanzenr. IV. 236, p. 367 (1902).

Efate: Undine Bay, common in rain-forest at 200 m., no. 237, April 28, 1928 (small tree up to 12 m. high; fruit purple when ripe; wood pink when freshly cut).—Also in New Caledonia.

Rapanea sp.

Aneityum: Anelgauhat Bay, common in rain-forest at 60 m., no. 751, Feb. 12, 1929 (large tree up to 12 m. high; leaves dark green with light yellow midrib; fruit black when ripe, 1 cm. long, 0.75 cm. in diam.).

Tapeinosperma Kajewskii Guillaumin, sp. nov.

Ramulis gracilibus (3 mm. diam.) primum sparse tomentellis, deinde glaberrimis, foliis obovatis (usque ad 14 cm. × 5.5 cm.) apice obtusis basi longe attenuatis sessilibus rigide membranaceis nervis a venis subtus reticulatis parum distinctis, punctis nigris minimis; inflorescentiae 2–3 cm. longae, ad ramulorum apicem congestae, ramis 2–3 rubiginosis et nigro lineatis leviter furfuraceis vel glabris, pedicellis 2 mm. longis, floribus 3 mm. longis sordide roseo-purpureis, sepalis ovatis apice obtusis basi tantum coalitis, margine furfuraceo-ciliatis, petalis late ovatis apice rotundatis basi ⅓ coalitis bene punctatis, staminibus petalis minoribus, antheris late ovatis epunctatis, filamentis nullis, ovario ovoideo, stylo bene distincto, stigmate peltatim discoideo. Fructus globosi (1.2 cm. diam.), apice umbonati, longitudinaliter brunneo-lineati.

Aneityum: Anelgauhat Bay, common in rain-forest at 210 m., no. 822, Feb. 28, 1929 (petals a dirty pink-purple with small

purple spots on the outside; fruit 1 cm. long, 1 cm. in diam. with elongated brown spots).

Tapeinosperma netor Guillaumin, sp. nov.

Arbor parva (ultra 7 mm.) vel alta (30 m.), ramulis sat gracilibus (circa 5 mm. diam.) glaberrimis, foliis lanceolatis (usque ad 20 cm. x 5 cm.) apice acutis basi in petiolum circa 1 cm. longum longe attenuatis membranaceis, nervis 16–19-jugis, tenuissimis immersis creberrime punctatis, inflorescentiae 8–9 cm. longae, graciles, ad ramulorum apicem congestae, pinnatim paniculatae, pedicellis circa 0.5 cm. longis, floribus 3 mm. longis, sepalis ovatis apice rotundatis tertia infima parte coalitis margine rigida breviterque ciliatis, petalis roseis ovatis apice obtusis basi $\frac{1}{5}$ tantum coalitis apice manifeste punctatis basi lineatis, staminibus petalis minoribus, antheris ovatis dorso valde punctatis, filamentis brevibus, ovario subulato. Fructus maturitate rubri, 1.5 cm. diam.

A n e i t y u m : Anelgauhat Bay, common in rain-forest at 240 m., no. 768, Feb. 12, 1929 (small tree up to 6 m. high; fruit red when ripe, very similar to shape of a cherry, 1 cm. long, 2 cm. in diam.). E r o m a n g a: Dillon Bay, common in rain-forest at 400 m., no. 313, May 28, 1928 (tree up to 30 m. high, growing about 6 miles inland among very tall rain-forest trees; petals pink).—Vernacular name "Net-or" (under no. 313).

These two species are rather closely related though they can be distinguished at the first glance; they are near *T. grande* Mez of the Fiji Islands.

SAPOTACEAE

Sideroxylon (Planchonella) **aneityense** Guillaumin, sp. nov.

Arbor 15–20 m. alta, ramis gracilibus primum sparse rufo-pilosis cito glabris, cortice brunneo abunde longitudinaliter striolato, gemmis rufo-pilosis, foliis lutescentibus membranaceis lanceolatis (usque ad 10 cm. x 3.5 cm.) utrinque glabris apice acutis basin versus longe attenuatis, nervis 7–9-jugis a venis reticulatis parum distinctis, petiolo gracili 1–2 cm. longo. Flores albo-virides, graveolentes, in axillis supremis dense fasciculati, pedicellis tenuibus ad 1 cm. longis sparse rufo-pilosis, calycis segmentis ovatis 1 mm. longis apice rotundatis extra sparse rufo-pilosis, corollae tubo 1 mm. longo lobis ovatis aequilongo, staminodiis filiformi-subulatis, staminibus filamentis sub fauce insertis, antheris ovatis aequilongis, ovario breviter lateque conico dense rufo-lanuginoso, stylo brevissimo cylindrico glabro.

A n e i t y u m: Anelgauhat Bay, common in rain-forest at 300 m., no. 771, Feb. 14, 1929 (large tree up to 15 m. high; leaves light

green; petals greenish white, sweetly scented); common in rain-forest at 300 m., no. **945**, March 19, 1929 (large tree up to 18 m. high; fruit immature; wood durable).—Vernacular name "Inretchar" (under no. 945).

Near *S. acutum* Krause of New Guinea.

Sideroxylon (Planchonella) **tannaense** Guillaumin, sp. nov.

Arbor 5 m. alta, trunco 75 cm. diam., ramis sat validis cinereis, foliis membranaceis ovatis (usque ad 15 cm. x 7 cm.) utrinque glabris apice valde obtusis basin versus cuneatis, nervis circa 9-jugis gracilibus a venis reticulatis parum distinctis, petiolo usque ad 4 cm. longo. Flores minimi, trunco circa 5-ni-fasciculati, pedicellis tenuibus 6–7 mm. longis tomentosis, calycis segmentis ovatis, 1 mm. longis dorso dense tomentosis, corollae tubo lobis breviore, lobis ovatis 1 mm. longis apice rotundatis, staminodiis filiformi-subulatis, staminum filamentis sub fauce insertis, antheris ?, ovario depresse globoso dense rufo-tomentoso, stylo conico glabro.

Tanna: Lenakel, common in rain-forest at 200 m., no. **104**, March 6, 1928 (tree up to 15 m. high, 75 cm. in diam.; fruit eaten by natives or so reported).

Near *S. novo-guineense* K. Schum. of New Guinea and perhaps also of the Moluccas.

Sideroxylon sp.

Aneityum: Anelgauhat Bay, common in rain-forest at 150 m., no. **936**, March 17, 1929 (large tree up to 15 m. high; leaves dark green; fruit immature; a good commercial timber for wood not exposed to weather). Eromanga: Dillon Bay, common in rain-forest at 300 m., no. **385**, June 8, 1928 (large tree up to 25 m. high with a very hard wood; leaves light brown underneath).—Vernacular name "Ney-mor" (under no. 385).

Sideroxylon sp.

Aneityum: Anelgauhat Bay, common in rain-forest at 300 m., no. **941**, March 19, 1929 (large tree up to 15 m. high; fruit immature).

Sideroxylon sp.

Eromanga: Dillon Bay, common in poor red soil, bracken country, at 300 m., no. **298**, May 24, 1928 (small shrub up to 5 m. high; fruit purple when ripe).—Vernacular name "Nor-sum."

Mimusops parvifolia R. Brown, Prod. Fl. Nov. Holl. I. 531 (1810).

Aneityum: Anelgauhat Bay, common in rain-forest at 30 m., no. **730**, Feb. 11, 1929 (large tree up to 6 m. high; flower white; young stems covered with brown hair). Eromanga: Dillon

Bay, common in rain-forest at 150 m., no. 266, May 17, 1928 (tree up to 20 m. high; fruit light red, bark rough and fissured). Efate: Fila Island, Vila, common in rain-forest at sea level, no. 179, April 12, 1928 (tree about 15 m. high reputed by natives to be poisonous).—Also New Caledonia, Loyalty Islands, Australia (Queensland, North Australia), and New Guinea.—Vernacular name "Yatarhwu" (under no. 266).

Manilkara dissecta (R. Br.) Dubard in Ann. Mus. Colon. Marseille, sér. 3, III. 13 (1915).

Aneityum: Anelgauhat Bay, scarce in the lower hills at 150 m., no. 983 (coll. *J. P. Wilson*), Sept. 1929 (large tree up to 1.30 m. in diam.; leaves small, elongated; flowers pink; fruit small, brown, only on extreme tips of branches; timber very hard, dark red, too scarce to be of commercial value); common in the rain-forest at 150 m., no. 937, March 17, 1929 (large timber tree up to 21 m. high; fruit immature; one of the best durable hard timbers on the island). —Also Tonga Islands.—Vernacular name "Niping."

Palaquium neo-ebudicum Guillaumin, sp. nov.

Arbor 25 m. alta, ramis validis primum rubiginoso-villosis deinde glabris, foliis rigide membranaceis ovatis (usque ad 12 cm. x 7 cm.) primum rubiginoso vestitis deinde glabris apice rotundatis basi cuneatis, petiolo 2.5–3.5 cm. longo, nervis 9–10-jugis bene distinctis, venis oblique parallelis. Flores ad ramulorum apicem, infra folia, dense fasciculati, pedicellis 1.5–3.5 cm. longis rubiginoso-tomentosis, calycis lobis ovatis, exterioribus 4 mm. longis, interioribus duplo brevioribus dorso rubiginoso-vestitis, corollae glabrae tubo brevi, lobis oblongis obtusis, antheris fere sessilibus anguste lanceolatis, dorso dense rubiginoso-pilosis, ovario glabro, stylo subulato valde elongato.

Aneityum: Anelgauhat Bay, common in rain-forest at 60 m., no. 756, Feb. 13, 1929 (large tree up to 18 m. high; outside of flower-buds covered with brown hairs). Eromanga: Dillon Bay, common in rain-forest at 400 m., center of the island, no. 344, June 1, 1928 (large tree up to 25 m. high; heart wood yellowish brown).—Vernacular name "Ney-more-yetu" (under no. 344).

Bassia Kajewskii Guillaumin, sp. nov.

Arbor ultra 20 m. alta, trunco 35–45 cm. diam., ramis crassis, foliis obovatis (usque ad 15 cm. x 9 cm.) atro-viridibus pergamentaceis apice rotundatis basi sensim cuneatis, nervis 10–12-jugis validis cum totidem intermediis, venis reticulatis, petiolo valido 1.5 cm. longo. Flores terminales fasciculati, pedicellis 1 cm. longis gracilibus appresse pilosis, calycis laciniis oblongis apice obtusis

extra dense appresse pilosis 3 mm. longis, corollae tubo 1 mm. longo lobis ovatis fere aequilongo glaberrimo, staminibus 16, antheris fere sessilibus anguste sagittatis, connectivo intus extraque dense lanuginoso, ovario conico stylo tereti coronato.

T a n n a: Lenakel, common in rain-forest soil at 150 m., no. 43, Feb. 23, 1928 (tree up to 20 m. high, 35–45 cm. in diam.; leaves dark green above, light green underneath; sap milky; fruit eaten by the natives).

Near **B. bawun** (Scheff.) Guillaumin, comb. nov., of New Guinea.

Bassia obovata Forster, Fl. Ins. Austr. Prod. 35 (1786).

A n e i t y u m: Anelgauhat Bay, common in rain-forest at sea level, no. 804, Feb. 21, 1929 (large tree up to 18 m. high; leaves dark green; flowers white; fruit light green up to 11.5 cm. long, flesh white inside, seeds large, black; fruit very luscious, eaten by the natives). B a n k s G r o u p: Vanua Lava, common in rain-forest at 100 m., no. 464, July 10, 1928 (large tree up to 20 m. high; flowers cream-colored; fruit eaten by the natives).—Already found on Tanna and Efate.

Bassia sp., affinis *B. obovata* Forst.

A n e i t y u m: Anelgauhat Bay, common in rain-forest at sea level, no. 833, Feb. 1, 1929 (large tree up to 12 m. high; fruit brown, immature on specimens; wood durable).

SAPOTACEARUM GEN.?

A n e i t y u m: Anelgauhat Bay, common in rain-forest at 150 m., no. 935, March 17, 1929 (large tree up to 18 m. high; leaves dark glossy green; fruit immature, covered with dense brown hairs).

EBENACEAE

Maba buxifolia Persoon, Syn. Pl. II. 606 (1807).

E r o m a n g a: Dillon Bay, common in rain-forest at 300 m., no. 391, June 8, 1928 (tree up to 15 m. high; natives say fruit is red when ripe; kernel of the nut is eaten by natives). A n e i t y u m: Anelgauhat Bay, common in rain-forest at 150 m., no. 932, March 17, 1929 (medium-sized tree up to 15 m. high; fruit immature; wood used for native houses).—Also New Caledonia, Loyalty, Tongo and Caroline Islands, New Guinea, Malaysia.—Vernacular name "Ni-Mung-lei" (under no. 391).

SYMPLOCACEAE

Symplocos aneityensis Brand in Engler, Pflanzenr. IV.-242, p. 39, (1901).

A n e i t y u m: Anelgauhat Bay, common in rain-forest at sea

level, no. 720, Feb. 11, 1929 (large tree up to 18 m. high; flowers white; wood used by natives for canoe paddles). Eromanga: Dillon Bay, common in poor red soil, bracken country, at 300 m., no. 295, May 24, 1928 (tree up to 10 m. high; flowers white; wood used in making paddles for canoes; this tree is found 4 or 5 miles inland).—Already found in Aneityum.—Vernacular name "Morelease" (under no. 295).

OLEACEAE

Jasminum didymum Forster, Fl. Ins. Austr. Prod. 3 (1786).

Eromanga: Dillon Bay, common in rain-forest at sea level, no. 259, May 15, 1928 (fruit black when ripe; used by natives as rope or cordage for binding their houses as it lasts a long time).—Already found on Efate; also New Caledonia, Loyalty Islands, Australia (Queensland, North Australia), Fiji, Tonga, Samoa, Cook and Society Islands, New Guinea.—Vernacular name "No-sori."

Jasminum simplicifolium Forster, Fl. Ins. Austr. Prod. 3 (1786).

Eromanga: Dillon Bay, common in rain-forest at 300 m., no. 404, June 8, 1928 (vine growing up to the tops of rain-forest trees; fruit black when ripe).—Already found on Aneityum; also New Caledonia, Loyalty Islands, Australia (Queensland, New South Wales, North Australia), Norfolk, Fiji, Tonga and Samoa Islands.—Vernacular name "No-sori."

APOCYNACEAE

Melodinus neo-ebudicus Guillaumin, sp. nov.

Alte scandens, ramis gracilibus 2 mm. diam. rubris, foliis oppositis lanceolatis (usque ad 9 cm. x 3 cm.) membranaceis integris apice longe acuminatis basi obtusis, nervis tenuibus crebris parallelis, petiolo gracili ad 4 mm. longo. Inflorescentiae axillares, cymosae, 3–5-florae, 1.5–3.5 cm. longae, pedicellis gracilibus usque ad 3 mm. longis apice 2-bracteolatis, sepalis 5 ovatis obtusis 1 mm. longis, corollae tubo roseo 5 mm. alto extra glabro intus tertia infima parte glabra, media sparse pilosa, suprema dense barbata, lobis 5 patulis ovatis (4 mm. x 2 mm.) albis, staminibus 5 anguste lanceolatis 1 mm. longis sessilibus ad 2/3 tubi insertis, ovario anguste ovoideo apice attenuato, stylo tereti gracili stigmateque conico apice 2-aristato inclusis 3 mm. longo. Fructus globosus 2 cm. diam. maturitate luteus, sicco atro-rubro-brunneus, pruinosus.

Aneityum: Anelgauhat Bay, common in rain-forest at 30 m., no. 729 (type of the flower), Feb. 11, 1929 (vine growing over rain-forest trees; petals white, corolla stem [? tube] pink). Eromanga: Dillon Bay, common in rain-forest at 300 m., no. 392 (type of

fruit), June 8, 1928 (vine growing over rain-forest trees; fruit yellow when ripe).

To be placed near *M. buxifolius* Baill. and *M. celastroides* Baill. of New Caledonia which probably constitute only one species.—Vernacular name "Nosarak" (under no. 392).

Alyxia efatensis Guillaumin, sp. nov.

Alte scandens, ramis sat crassis, foliis 3-nis lanceolatis (usque ad 10 cm. x 3.5 cm.) rigide membranaceis apice obtusis vel acutis rarissime acuminatis basi cuneatis, venis immersis tenuibus crebis fere rectis, petiolo circa 1 cm. longo. Inflorescentiae ad ramulorum apicem axillares, ad 5 cm. longae, umbellatim cymosae, foliis 2 parvis (2.5–3 cm. x 0.9–1 cm.) oppositis, apice bracteatae, floribus luteis 3 in pedunculo communi 5 mm. longo sessilibus vel 5 exterioribus pedicello 2.5 mm. longo suffultis, tantum inapertis 2 cm. longis, bracteola 1 lanceolata ima calycis basi, sepalis 5 lanceolatis 2.5 mm. longis apice molliter ciliolatis, corollae tubo 1.2 cm. longo cylindrico apice leviter strangulato et intus sub staminibus breviter barbato, lobis brevibus (5 mm. longis) anguste ovatis, staminum filamentis antheris 2-plo brevioribus sub fauce insertis, antheris tubi apicem attingentibus, locis fere parallelis apice obtuse mucronatis, ovario conico apice attenuato, stylo longo staminum basin attingente tereti apice leviter dilatato (?).

Efate: Undine Bay, common in rain-forest at 500 m., no. 231, April 28, 1928 (vine climbing up to tops of rain-forest trees; flowers yellow).

The most closely related species, though differing in its pubescent ovary seems to be *A. laurina* Gaudich. from the islands Rawak and Gebeh of the Moluccas.

Alyxia, sp. nov.?

Banks Group: Vanua Lava, common in rain-forest at 300 m., no. 477, July 12, 1928 (vine growing over rain-forest trees).

Cerbera manghas Linnaeus, Sp. Pl. 208 (1753).

Aneityum: Anelgauhat Bay, common in rain-forest at sea level, no. 806, Feb. 21, 1929 (common scrub tree up to 12 m. high; flowers sweetly scented, petals dirty brown with white edges; fruit 9 cm. long, 5.5 cm. in diam., purple when ripe).—Already found on Tanna and Efate; also New Caledonia, Loyalty, Fiji, Tonga, Samoa, Society, Marquesas, Gambier, Marshall, Caroline, Mariana, Solomon, Bismarck and Admiralty Islands, New Guinea, Aru Islands and Malaysia.

Ochrosia alyxioides Guillaumin, sp. nov.

Arbor parva, 7 m. alta, lactescens; ramis gracilibus, foliis 3–4-nis

rigide membranaceis linearibus (usque ad 12 cm. x 1 cm.) apice attenuatis basi longe attenuatis, nervis immersis creberrimis rectis, petiolo circa 1 cm. longo gracile. Inflorescentiae axillares, circa 3 cm. longae, ramosae, papillosae, bracteis ovatis, pedicello subnullo, sepalis ovatis 1.5 mm. longis extra papillosis dorso carinatis, corolla (tantum juvenili) sepalis aequilonga ad medium 5-loba, lobis ovatis, antheris sagittatis sessilibus tubo fere aequilongis, ovario conico lateraliter compresso medioque sulcato, stylo subulato aequilongo. Fructus (2.5 cm. x 2 cm.), maturitate rubri, drupis 2, epicarpio tenuissimo, endocarpii una facie convexa, altera applanata medioque sulcata.

Aneityum: Anelgauhat Bay, common on sea shore at sea level, no. 925, March 17, 1929 (small tree up to 6 m. high; fruit 2.5 cm. long, 1.75 cm. in diam., red when ripe; sap milky).

Very remarkable on account of its flowers and leaves which quite resemble those of *A. bracteolosa* Rich. ex A. Gray var. *angustifolia* A. Gray from the Tonga Islands.

Ochrosia elliptica Labillardière, Sert. Austro-Caled. 25, t. 30 (1824).

Aneityum: Anelgauhat Bay, common in rain-forest at sea level, no. 693, Feb. 4, 1929 (small tree up to 6 m. high, sap milky; leaves dark green; fruit red when ripe, 3.75 cm. long). Eromanga: Dillon Bay, common in rain-forest close to sea beach, at sea level, no. 360, June 4, 1928 (large shrub up to 6 m. high; fruit red).—Also New Caledonia, Australia (Queensland), Fiji, Tonga and Society Islands.—Vernacular name "Naugh-comb" (under no. 360).

Ochrosia parviflora Henslow in Ann. Nat. Hist. I. 345 (1838).
Ochrosia elliptica K. Schumann, non Labillardière.

Aneityum: Anelgauhat Bay, common on seashore at sea level, no. 947, March 19, 1929 (medium sized tree up to 9 m. high; flowers white; fruit 8 cm. long, 5.5 cm. in diam.). Eromanga: Dillon Bay, common in rain-forest at sea level, no. 405, June 8, 1928 (large tree up to 15 m. high; flowers white; seed eaten by the natives). Efate: Undine Bay, common in rain-forest at sea level, no. 207, April 25, 1928 (tree up to 20 m. high; white sap flows freely from branches but not from the trunk).—Also Fiji, Solomon, Bismarck and Admiralty Islands, New Guinea, Aru Islands, Malaysia.—Vernacular name "Yefat" (under no. 405).

Alstonia villosa Seem. form. **calvescens** Markgraf in Bot. Jahrb. LXI. 198 (1927).

Aneityum: Anelgauhat Bay, common in rain-forest at 60 m., no. 740, Feb. 12, 1929 (small tree up to 9 m. high; flowers white).

Eromanga: Dillon Bay, common in rain-forest and red soil, bracken country, no. 292, May 23, 1928 (small tree up to 8 m. high; flowers white; fruit hangs down like a long appendage, 25 cm. long).—Also Bismarck and Key Islands, North Australia, Malaysia.—Vernacular name "Ne-yev-vi-are" (under no. 292).

Ervatamia orientalis (R. Br.) Turrill in Jour. Linn. Soc. XLIII. 32 (1915).

Tabernaemontana orientalis R. Brown Fl. Nov. Holl. Prodr. 468 (1810).

Aneityum: Anelgauhat Bay, common in rain-forest at sea level, no. 692, Feb. 4, 1929 (small tree up to 10 m. high, sap milky; leaves bright green; flowers white; fruit brownish red when ripe). Tanna: Lenakel, common in heavy rain-forest soil at 45 m., no. 13, Feb. 20, 1928 (small tree with numerous branches; leaves bright green; flowers white).—Already found on Aneityum, Tanna, Eromanga and Efate; also Loyalty Islands, Australia (North Australia, Queensland, New South Wales), Fiji, Tonga and Society Islands, New Guinea, Malaysia.

Parsonsia neo-ebudica Guillaumin, sp. nov.

Scandens, foliis oppositis rigide membranaceis vel sub-coriaceis ovatis (usque ad 12 cm. x 6 cm.) apice breviter acuteque acuminatis basi rotundatis glaberrimis, nervis immersis 8–9-jugis arcuatis, petiolo 2–3 cm. longo. Inflorescentiae axillares, 4–6 cm. longae, laxiflorae, 9–11-florae, pedunculo 3–4 cm. longo, ramis 0.5–1.5 cm. longis, bracteis minimis subulatis, pedicellis usque ad 5 mm. longis ut pedunculo glaberrimis, calycis lobis acute triangularibus, 1.5 mm. longis glaberrimis, corolla 8 mm. longa, lobis anguste lanceolatis tubo sub-2-plo longioribus infra supraque faucem dense deorsum barbata, staminum filamentis 2 mm. longis, antheris filamentis 2-plo longioribus basi longe sagittatim appendiculatis, disco 5-crenato ovario aequialto, ovario glabro, stylo gracili, stigmate cylindrice dilatato antherarum tertiam supremam partem attengente.

Eromanga: Dillon Bay, common in rain-forest at 300 m., no. 396, June 8, 1928 (vine growing over the tops of rain-forest trees; used by natives in binding trees).—Vernacular name "No-satamus."

Seems to approach especially *P. spiralis* Wall. of New Guinea, of the Aru and Key Islands, the Philippines, Malaysia and Asia, but its flowers are much smaller, the sepals acute and the corolla pubescent inside part of its length.

ASCLEPIADACEAE

Asclepias curassavica Linnaeus, Sp. Pl. 215 (1753).—Willdenow, Sp. Pl. I. 1266 (1798).

A n e i t y u m: Anelgauhat Bay, common in open country at sea level, no. **930**, March 17, 1929 (small weed up to 1 m. high; flowers orange and yellow; the natives say this is indigenous to the islands as they have a native name for it). E r o m a n g a: Dillon Bay, common in open grassy country at 300 m., no. **388**, June 8, 1928 (weed up to 1 m. high; flowers red; suspected poisonous weed). —Already found on Aneityum; also New Caledonia, Loyalty Islands, Australia (Queensland), Tonga, Samoa, Cook, Society, Marquesas, Marshall and Mariana Islands, Malaysia, Hawaii (introduced).—Vernacular name "Te-vess" (under no. 388).

Hoya australis R. Brown apud Traill in Trans. Hort. Soc. VII. 28 (1830).

A n e i t y u m: Utgi, plentiful on seashore at 90 m., no. **1002**, (coll. *J. P. Wilson*), Sept. 1929 (vine; leaves medium, light green, fleshy; flowers small, white; fruit long spike-like pods, 12.5 cm. long, 1.2 cm. in diam.).—Already found on Tanna and Efate; also Queensland, Fiji, Samoa, Solomon? and Bismarck?? Islands.—Vernacular name "Napalht."

The specimen cited differs from the description of R. Brown only in the petals being entirely papillose on their whole upper surface. The young parts (branchlets and the leaves on both sides) are copiously villous which corresponds with Seemann's remarks (Fl. Vit. p. 163) concerning his *H. pilosa*. It would be very desirable to make a complete revision of the specimens referred to this species. Schlechter (in Bot. Jahrb. L. 118) has already drawn attention to the confusion particularly in regard to the specimen of Naumann from the Solomon Islands which he considers as the type of a distinct species: *H. Naumannii* Schlechter, while Engler refers it to *H. australis* R. Br.

Tylophora aneityensis Guillaumin, sp. nov.

Scandens, ramis gracilibus flexuosis teretibus glaberrimis, foliis (in sicco) rigide membranaceis ovatis (usque ad 6 cm. x 4 cm.) apice attenuatis mucronatisque basi rotundatis et saepius glandulosis, petiolo 1.5–2 cm. longo. Inflorescentiae extra-axillares, 5–9 cm. longae, paniculatae, parte florifera 0.5 cm. longa racemosa, bracteis numerosis minimis ciliatis imbricatis, floribus subflavis numerosis, pedicello capillari, corolla fere aequilongo, calycis lobis ovatis obtusis 1.5 mm. longis margine sparse ciliolatis basi tantum coalitis, corollae lobis ima basi tantum coalitis lineari-ellipticis (8 mm. x 3 mm.) apice rotundatis 7-nervis, coronae squamis triangulari-ovatis 1 mm. altis obtusiusculis, carnosis antherarum basin superantibus, antheris parallelipipedis basi acutis apice ap-

pendice hyalina semi-orbiculari, polliniis globosis, translatoribus brevibus, retinaculo ovoideo-elongato polliniis aequilongo, stigmatis capite plano stamina haud superante. Folliculus (tantum immaturus) globosa-compressus (2 cm. x 1.8 cm.), apice apiculatus, pedicello 6 mm. longo.

Aneityum: Anelgauhat Bay, common on sea shore at sea level, no. 796, Feb. 21, 1929 (vine growing over undergrowth on sea shore; petals cream-colored).

The most closely related species seems to be *T. Brackenridgei* A. Gray from the Fiji Islands. The genus was already known from the Torres Islands by a specimen not specifically determined.

Tylophora tannaensis Guillaumin, sp. nov.

Scandens, ramis gracilibus flexuosis teretibus glaberrimis, foliis (in sicco) membranaceis ovatis (usque ad 6.5 cm. x 4 cm.) apice mucronatis rotundatis vel etiam emarginatulis basi rotundatis glandulosisque, petiolo circa 2 cm. longo. Inflorescentiae extra-axillares, usque ad 8 cm. longae, umbellatae, rarius paniculatim umbellatae, pedunculo communi 1.5–2.5 cm. longo, glabro, bracteis minimis extra puberulis floribus albis numerosis, pedicello capillari corolla 2-plo longiore vel ultra sparsissimeque puberulo deinde glabrescente, calycis lobis late ovatis apice rotundatis 2 mm. longis dorso sparse puberulis basi tantum coalitis, corollae lobis ima basi tantum coalitis lineari-ellipticis (1 cm. x 3.5 mm.) apice rotundatis 7-nervis, coronae squamis ovato-acutis, 1.5 mm. altis acutis carnosis, ad antherarum medium attingentibus, antheris parallelipidedis basi obtusis apice appendice hyalina semi-orbiculari, polliniis globosis, translatoribus brevibus, retinaculo ovoideo-elongato, stigmatis capite plano stigma non superante.

Tanna: Lenakel, common in rain-forest at sea level, no. 20, Feb. 21, 1928 (vine climbing up on rain-forest trees; flowers white).

Extremely close to the preceding species, but different in its inflorescence, the much longer pedicels and the presence of soft scattered hairs on the pedicels and the back of the sepals and in the acute apex of the scales of the corolla.

LOGANIACEAE

Geniostoma rupestris Forster, Char. Gen. 24, t. 12 (1776).

Aneityum: Anelgauhat Bay, common in rain-forest at 30 m., no. 728, Feb. 11, 1929 (small tree up to 9 m. high; leaves dull, dark green; petals white).—Already found on Tanna; also Fiji, Tonga, Samoa, Cook and Society Islands.

Fagraea sp.

Aneityum: Anelgauhat Bay, common in rain-forest at 100 m.,

no. 734, Feb. 11, 1929 (large tree up to 18 m. high; leaves dark green, flowers yellow).

Couthovia neo-ebudica Guillaumin, sp. nov.

Arbor parva, 12 m. alta, foliis ovatis (13–20 cm. x 6–10 cm.) basi cuneatis apice rotundato-obtusis vel latissime acuminatis, sat crassis, petiolo pro genere gracili 1.5–3 cm. longo, nervis 5–6-jugis, venis immersis, stipulis interpetiolaribus majusculis coriaceis brevissime obtusis, cum petiolis in cupulam usque ad 1 cm. altam coalitis nunquam fissis. Inflorescentia composite cymosa, pedunculo robusto 1.5 cm. longo, ramis I. ord. 7–7.5 cm. longis brevissime sparsissimeque tomentellis, II. ord. 2–3 cm. longis et III. ord. 3–8 mm. longis densius longiusque tomentellis, pedicellis nullis vel brevissimis et dense tomentellis, bracteis minimis suborbicularibus margine dense ciliatis 1 mm. longis corolla . . . , staminibus . . . , ovario ovoideo-elongato in stylum indistincte attenuato, stigmate capitato. Fructus elongati (fere 4 cm. x 1 cm.), inferne in stipitem curvatum attenuatis, apice sensim longe acuteque attenuati.

Aneityum: Anelgauhat Bay, common in rain-forest up to 180 m., no. 774, Feb. 18, 1929 (small tree up to 12 m. high; flowers sweetly scented; fruit when gathered 4 cm. long, 1 cm. in diam.).

To be placed near *C. densiflora* K. Schum. and *C. terminalioides* Gilg & Bened. from New Guinea.

BORAGINACEAE

Cordia Myxa Linnaeus, Sp. Pl. 190 (1753).

Aneityum: Anelgauhat Bay, common in rain-forest at sea level, no. 691, Feb. 4, 1928 (small tree up to 15 m. high; fruit pinkish brown when ripe, 4 cm. long, 3 cm. in diameter). Eromanga: Dillon Bay, rain-forest, 300 m., common, no. 397, June 8, 1928 (fruit red when ripe; bark used for grass skirts and berries to feed pigs). Tanna: Lenakel, common in rain-forest at 100 m., no. 42, Feb. 22, 1928 (tree 7 to 10 m. high; fruit pink when ripe).—Already found on Tanna; also New Caledonia, Australia, (Queensland), Society and Marquesas Islands, New Guinea, Malaysia.—Vernacular name "Yalehoi" (under no. 397).

Tournefortia argentea Linnaeus f., Suppl. 133 (1781).

Aneityum: Anelgauhat Bay, common on sea shore at sea level, no. 795, Feb. 20, 1929 (small tree up to 9 m. high; flowers white). Tanna: Lenakel, common on sea shore at sea level, no. 78, March 3, 1928 (tree about 10 m. high with very spreading top). Eromanga: Dillon Bay, common along sea coast at sea level, no. 406, June 8, 1928 (small, well-branched tree up to 10 m. high, only

along sea shore). Banks Group: Vanua Lava, common on sea shore at sea level, no. 425, July 6, 1928 (small tree up to 8 m. high; common on all the shores of the New Hebrides).—Already found on Efate; also New Caledonia, Loyalty Islands, Australia (Queensland, North Australia), Fiji, Tonga, Samoa, Cook, Society, Paumota, Union, Ellice, Gilbert, Marshall, Caroline, Mariana, Solomon, Bismarck and Admiralty Islands, New Guinea, Malaysia, Hawaii.—Vernacular name "Ney-in-pori" (under no. 406).

CONVOLVULACEAE

Ipomoea congesta R. Brown, Fl. Nov. Holl. Prod. 485 (1810).

Banks Group: Vanua Lava, common in rain-forest at sea level, no. 449, July 9, 1928 (climber; flower very pretty, puce-colored with a white base; grows freely both in scrub and plantations).—Already found on Tanna and on Efate; also New Caledonia, Australia (Queensland), Norfolk, Fiji, Tonga and Mariana Islands, New Guinea, Hawaii.

? Ipomoea denticulata Choisy in Mém. Soc. Phys. Genève, VI. 447 (1833).

Eromanga: Dillon Bay, common in open grass country at 300 m., no. 320, May 28, 1928 (vine growing over small bushes; flowers white).—Already found on Aneityum and Efate; also Australia (Queensland), Tonga, Fiji, Society, Marshall, Solomon and Bismarck Islands, New Guinea, Malaysia.—Vernacular name "Niye-eni-usak-wavi."

Ipomoea pes-caprae Roth, Nov. Pl. Sp. 109 (1821).

Aneityum: Anelgauhat Bay, common on sea shore at sea level, no. 815, Feb. 26, 1929 (creeping vine growing on the sand close to the sea beaches; flowers purple; found throughout the entire group). Eromanga: Dillon Bay, common on sea beach at sea level, no. 332, May 29, 1928 (vine growing close to the sea and in some plantations adjoining the sea it is a pest; flowers purple).—Also New Caledonia, Australia (Queensland, New South Wales, North Australia, West Australia), New Zealand, Fiji, Tonga, Samoa, Cook, Marquesas, Ellice, Marshall, Mariana, Solomon, Bismarck and Admiralty Islands, Malaysia, Hawaii.—Vernacular name "Novi-wavu" (under no. 332.

Ipomoea turpethum R. Brown, Fl. Nov. Holl. Prod. 485 (1810).

Banks Group: Vanua Lava, common in rain-forest at sea level, no. 450, July 9, 1928 (common in the New Hebrides; flower large, snow white).—Already found on Aneityum, Tanna and Eromanga; also New Caledonia, Loyalty Islands, Australia (Queensland), Fiji, Tonga, Samoa, Society and Bismarck Islands, Malaysia.

SOLANACEAE

Datura arborea Linnaeus, Sp. Pl. 179 (1753).

T a n n a: Ikiti, common in rain-forest at 100 m., no. 175, March 16, 1928 (shrub up to 4 m. high; flowers cream).

A South American species already introduced to Australia (West Australia) and to Tahiti.

GESNERIACEAE

Cyrtandra aneiteensis C. B. Clarke in De Candolle, Monog. Phan. v. 282 (1883).

Descriptioni adde: Corolla sub-flava extra ad tubi apicem lobisque villosula, ceterum glabra, tubo cylindrico 12 mm. longo, lobis 5 rotundatis, 3 posterioribus 4 mm. longis, 2 anterioribus 3 mm. longis, staminibus 2 ad apicem tubi insertis, filamentis antheribusque aequilongis annulum horizontalem formantibus, antheris albis apice coherentibus.

A n e i t y u m: Anelgauhat Bay, common in rain-forest at 180 m., no. 773, Feb. 18, 1929 (plant up to 1.80 m. high, growing in rain-forest clearings; petals creamy green).—Already found on Aneityum.

Except that the calyx is still persistent on the young fruit, all the other characters agree with the description by Clarke. The hitherto unknown corolla is described above.

Cyrtandra cymosa J. & G. Forster, Char. Gen. 6 (1776).

B a n k s G r o u p: Vanua Lava, common in rain-forest at 200 m., no. 452, July 10, 1928 (small tree up to 3 m. high; flowers creamy yellow).—Already found on Aneityum and Tanna.

The specimen differs from the type in the much longer petioles (up to 7 cm. long) scarcely undulate on the margin.

Cyrtandra Kajewskii Guillaumin, sp. nov.

Frutex 2 m. alta, ramis novellis dense rufo-hirsutis, deinde glabris, foliis oppositis aequalibus elongato-ellipticis (usque ad 30 cm. x 11 cm.) basi longe attenuatis apice obtusis margine serratis membranaceis, novellis dense rufo-hirsutis deinde margine et costa subtus exceptis glaberrimis, nervis circa 12-jugis, petiolo 2–3 cm. longo, rufo-hirsuto. Inflorescentiae petiolo aequilongae, pedunculo subnullo, bracteis lanceolatis (1 cm. x 0.4 cm.) margine pilosis, pagina inferiore hirsutis, pedicellis fasciculatis 1 cm. longis sparse hirsutis, calyce 7 mm. alto ad tertiam partem fisso intus extraque glaberrimo, lobis 5 lanceolatis acuminatis, corolla extra ad tubi apicem lobisque sparse villosa, ceterum glabra, tubo 2 cm. longo apicem versus dilatato, lobis rotundatis, 5 mm. longis, staminibus 2, ad tubi apicem insertis, filamentis brevissimis horizontaliter

annularibus, antheris . . . , ovario glaberrimo in stylum attenuato 1.5 cm. longo, apice sparsissime hirsuto, stigmate discoideo peltato, disco tubuloso 2 mm. alto apice 5-undulato. Fructus, tantum novelli, fusiformes, basi calyce cincti.

T a n n a: Lenakel, common in rain-forest soil at 200 m., no. 62, Feb. 24, 1928 (shrub about 2 m. high, found on banks of gullies).

This species is similar to *C. aneiteenis* C. B. Clarke but is clearly distinct by its much larger flowers with a tube enlarged above and by the perfectly glabrous calyx.

ACANTHACEAE

Hemigraphis reptans T. Anderson apud Hemsley, Rep. Sci. Res. Voy. Challenger, Bot. I. pt. III, 173 (1885).

A n e i t y u m: Anelgauhat Bay, common in rain-forest at 240 m., no. 903, March 11, 1929 (small plant up to 80 or 100 cm. high; flowers pink).—Already found on Aneityum, Tanna, Efate, Eromanga and Espiritu Santo; also New Caledonia, Loyalty, Tonga, Marshall, Solomon, Bismarck and Admiralty Islands, New Guinea, Malaysia.

Acanthus ilicifolius Linnaeus, Sp. Pl. 639 (1753).

E f a t e: Undine Bay, common at sea level in rain-forest on salt water creek, no. 195, April 24, 1928 (growing in large clumps or patches, the canes of which have a sprawling habit; flowers puce-colored; fruit brown when ripe).—Already found on Tanna; also New Caledonia, Australia (Queensland, North Australia), Bismarck Islands, New Guinea, Malaysia.

Pseuderanthemum laxiflorum (Gray) Hubbard in Rhodora, XVIII. 159 (1916).

T a n n a: Lenakel, common in native gardens, rain-forest at 150 m., no. 83, March 3, 1928 (shrub about 4 m. high; flowers white with violet centers).—Already found on Eromanga (ined.); also Fiji Islands.

Pseuderanthemum sp.

B a n k s G r o u p: Vanua Lava, common in rain-forest at 300 m., no. 457, July 12, 1928 (plant up to 75 cm. high; petals white with pale pink bases.

VERBENACEAE

Stachytarpheta indica Vahl, Enum. I. 206 (1805).

T a n n a: Lenakel, common in rain-forest soil at 100 m., on all levels, no. 40, Feb. 22, 1928 (common weed 1–1.5 m. high; flowers bright blue).—Also found on New Caledonia, Loyalty, Samoa, Caroline Islands, Malaysia.

Vitex Negundo Linnaeus, Sp. Pl. 638 (1753).

Aneityum: Anelgauhat Bay, common on seashore at sea level, no. 801, Feb. 21, 1929 (shrub up to 3 m. high, growing on the beach; leaves silvery underneath; flowers blue; fruit yellow when ripe).—Also New Caledonia, Mariana Islands, Malaysia.

Vitex rapinioides Guillaumin, sp. nov.

Arbor usque ad 20 m. alta, trunco 60 cm. diam., ligno luteo, ramis luteis primum puberulis, foliis usque ad 15 cm. longis, 3–5 foliolatis, foliolis ovatis (9 cm. x 5 cm., 7 cm. x 4 cm., 3 cm. x 1.5 cm.) basi obtusis vel cuneatis apice acuminatis rigide membranaceis, nervis 5–9-jugis, petiolulis 1 cm., 0.5 cm., 0.25 cm. longis, petiolo 2.5–5 cm. longo, primum lamina, petiolis, petiolulo rufo-puberulis, deinde lamina glabra infra glanduloso-punctata, petiolulis et petiolo glabrescentibus. Inflorescentia cymosa, ad 4 cm. longa, 3-flora, pedunculo gracili 1–1.5 cm. longo sparse rufo-puberulo, apice bracteis 2 filiformibus 2–3 mm. longis rufo-puberulis munito, pedicellis 1.5–2 cm. longis, lateralibus medio bracteolis 2 oppositis rufo-glanduloso-puberulis 1 mm. longis munitis, floribus roseis, calyce campanulato integro 4 mm. alto extra dense rufo-glanduloso margine rufo-lanuginose 4-penicellato, corolla circa 2 cm. longa extra basi excepta dense rufo-puberula, tubo circa 1.5 cm. longo intus supra staminum insertionem lanuginoso, lobis rotundatis, majore 6 mm. longo, intus lanuginosis, staminibus exsertis, filamentis 3 mm. supra basin insertis lanuginosis, ovario globoso glabro 4-loculari, stylo elongato, apice 2-fido. Fructus rubri, depresse globosi (1.3 cm. x 1.5 cm.), calyce patellato 6 mm. diam., putamine circa 5 mm. crasso 4-loculari.

Aneityum: Aname, west coast, common on seashore to 15 m., no. 992 (coll. *J. P. Wilson*) (type), Sept. 1929 (large tree to 60 cm. in diam.; leaves medium; flowers small, pink, bell-shaped; fruit red 1.2 cm. long, 1–5 cm. in diam.). Eromanga: Dillon Bay, common in rain-forest at 300 m., no. 299, May 24, 1928 (large tree up to 20 m. high; fruit red; common in the southern group; wood very hard and used by the natives in house building). Efate: Undine Bay, common in rain-forest at 100 m., no. 211, April 26, 1928 (tree with yellow wood and very faulty, up to 20 m. high; flowers pink; fruit pink). Vernacular names "Incdic" (under no. 992) and "Nay-mofsi" (under no. 299).

Nearest to *V. Rapini* Beauv. of New Caledonia which has the leaves much thinner and of different shape. The specimen from Efate is remarkable for its more elongated oval-lanceolate or lanceolate leaves.

Vitex trifolia Linnaeus, Sp. Pl. 638 (1753).

Aneityum: Anelgauhat Bay, common on the sea shore at sea level, no. 690, Feb. 4, 1929 (small plant up to 25 cm. high growing on sand beach; leaves silver-green; flowers light blue). Tanna: Lenakel, not common, in rain-forest soil at 200 m., no. 66, Feb. 24, 1928 (small tree about 4 m. high); common in native gardens of rain-forest soil at 150 m., no. 84, March 3, 1928 (shrub about 4 m. high; leaves variegated with white; flowers blue).—Already found on Aneityum, Tanna, and Epi; also New Caledonia, Australia (Queensland, North Australia), Norfolk, Fiji, Tonga, Samoa, Cook, Marquesas, Caroline, Mariana and Bismarck Islands, New Guinea, Malaysia, Hawaii.

Faradaya neo-ebudica Guillaumin, sp. nov.

Alte scandens, cortice fulvo, foliis oppositis late vel latissime ovatis (usque ad 14 cm. x 11 cm.) apice brevissime subitoque acuminatis vel subrotundatis basi cuneatis, leviter coriaceis, nervis 4–6-jugis, venis reticulatis ut nervis subtus tantum prominulis, petiolo 1–4 cm. longo. Inflorescentiae axillares, 5–7 cm. longae, centrifuge corymboso-dichotome cymosae, sparse puberulae, bracteis lanceolatis (1 cm. x 0.3 cm.) basin versus longe attenuatis in utraque pagina rufo-puberulis, floribus albis, centrali pedicello rufo puberulo 1 cm. longo suffulto, calyce primum clauso sparse puberulo deinde in lobos 4 valvatim fisso tunc 8 mm. longo, corollae lobis 1 exteriore majore, 1 intermedio leviter minore, ut exteriore margine integerrimo, 2 interioribus minoribus margineque suberosis, tubo 3-plo brevioribus, staminibus 4 medio tubi insertis leviter exsertis, antheris in alabastro inflexis ellipticis, loculis parallelis, ovario breviter 4-lobo 4-loculari, loculis 1-ovulatis, ovulis alte insertis, stylo staminibus breviore, stigmate 2-lamellato.

Aneityum: Anelgauhat Bay, common in rain-forest at 120 m., no. 813, Feb. 29, 1929 (vine growing to the tops of rain-forest trees; flowers white).

I believe that on account of the calyx and the ovary, notwithstanding the fact that the scarcely exserted stamens are inserted at the middle and not at the mouth of the corolla-tube, this species should be referred to the genus *Faradaya* of New Guinea which extends to the Samoa Islands, Queensland and Borneo, but does not seem to occur in the Moluccas and in Malaysia.

Premna integrifolia Linnaeus, Mant. Alt. 252 (1771).

Efate: Undine Bay, common in rain-forest at sea level, no. 208, April 25, 1928 (spreading tree growing close to the beach). Banks Group: Vanua Lava, common in rain-forest at sea level, no. 439, July 9, 1928 (large tree up to 15 m. high, very common throughout

the New Hebrides; flowers cream).—Already found on Efate; Also New Caledonia, Loyalty, Marshall, Mariana, and Bismarck Islands, New Guinea, Malaysia.

Clerodendron inerme Gaertner, Fruct. I. 271 (1788).

E f a t e: Fila Island, Vila, common on seashore at sea level, no. 185, April 13, 1928 (shrub about 3 m. high; flowers white).—Also New Caledonia, Loyalty Islands, Australia (Queensland, New South Wales, North Australia), Fiji, Tonga, Samoa, Caroline, Mariana, Santa Cruz, Solomon, Bismarck and Admiralty Islands, New Guinea, Malaysia.

LABIATAE

Ocimum sanctum Linnaeus, Mant. 85 (1767).

T a n n a: Lenakel, common in native gardens of rain-forest, at 200 m., nos. 64 and 65, Feb. 24, 1928 (herb. about 33 cm. high).—Already found on Efate and Espiritu Santo; also Australia (North Australia), Solomon, Bismarck and Mariana Islands, New Guinea, Malaysia.

Coleus scutellarioides Bentham in Wallich, Pl. As. Rar. II. 16 (1831).

E r o m a n g a: Dillon Bay, common in poor red soil, bracken country, at 400 m., no. 316, May 28, 1928 (small plant up to 75 cm. high; flowers blue).—Already found on Tanna, Eromanga, Efate and Espiritu Santo; also New Caledonia, Australia (North Australia) Bismarck Islands, New Guinea, Malaysia.—Vernacular name "Ou-lair-ung."

Plectranthus Forsteri Bentham, Lab. Gen. et Sp. 38 (1832).

E r o m a n g a: Dillon Bay, common on sea shore at sea level, no. 258, May 15, 1928 (small plant about 50 cm. high; flowers pale blue; used by natives for sores, sap taken and mixed with salt water).—Already found on Aneityum, Tanna and Eromanga; also Isle of Pines, Fiji and Samoa Islands.

(To be continued)

MUSEUM NATIONAL D'HISTOIRE NATURELLE,
PARIS.

KALMIOPSIS, A NEW GENUS OF ERICACEAE FROM NORTHWEST AMERICA

ALFRED REHDER

Plate 40

THE DISCOVERY in Oregon by Mr. and Mrs. Leach of a new ericaceous shrub subsequently described by L. F. Henderson as *Rhododendron Leachianum*[1] is highly interesting, particularly as this shrub turns out to be a new genus related to *Loiseleuria* and *Kalmia* and also to *Rhododendron* for which I propose the name *Kalmiopsis* referring to its general resemblance to *Kalmia polifolia* Wangenh. In its inflorescence it agrees closely with *Kalmia polifolia* Wangenh. except that it has alternate instead of opposite bracts. The inflorescence in both species is a short raceme terminating last year's branchlets; the bracts decrease in size toward the apex, the lowest being more or less leaf-like; the persistent bractlets surround the pedicels at the base and together with the bract act as protecting scales for the flower-buds during the winter, The calyx in both species is 5-parted, rather large, colored and gibbous at the base, forming a ring around the immersed apex of the slender pedicel. The corolla is similar in size and color in both species, but in *Kalmiopsis* more campanulate and lacking the peculiar pouches of *Kalmia*. The capsule is subglobose and thin-walled and the valves bifid at the apex in both genera. In *Kalmiopsis* the under side of the leaves and the inflorescence are dotted with lepidote glands absent in the genus *Kalmia*. *Loiseleuria* has the same inflorescence as *Kalmia polifolia* though reduced to fewer flowers, the calyx too, is similar, but the number of stamens is only 5, the anthers are dehiscent by longitudinal slits and the ovary is 2–3-celled. The capsule is similar to *Kalmia* and *Kalmiopsis*. Like *Kalmia* it lacks the glandular dots on the leaves and inflorescence. *Rhododendron* differs chiefly in its seeds which are enclosed in a loose and thin elongated testa lacerated or fringed at the ends and in the capsule which is more or less elongated, has woody walls and the valves not bifid at the apex. Its inflorescence, too, is very different, being an umbel-like raceme sometimes reduced to one flower, enclosed in scaly winter-buds before anthesis except in the subgenus *Therorhodion* which has a one- to two-flowered inflorescence terminating leafy shoots of the current year; it may well be considered a distinct genus as proposed by Small, connecting *Rhododendron* with *Rhodo-*

[1] L. F. Henderson in Rhodora, XXXIII. 205 (1931).

thamnus. The flowers in Rhododendron are more or less zygomorphous while in *Kalmiopsis* as in the two genera mentioned above they are actinomorphous. The peculiar lepidote glands are copiously present in the numerous species of the subgenus *Eurhododendron* Endl. except its section *Leiorhodion* Rehd. In its inflorescence and in the structure of its flowers *Kalmiopsis* shows a rather close relation also to *Phyllodoce* Salisb. and *Rhodothamnus* Reichenb. Both differ in the absence of lepidote glands on the under side of the leaves and on the inflorescence; *Phyllodoce* also in the crowded linear strongly reflexed leaves, the ovoid to campanulate corolla and the elongated style, and *Rhodothamnus* Reichenb. in the slightly zygmorphous flower, rotate corolla, long exserted style and long-ciliate leaves.

The new genus represents apparently, like *Loiseleuria* and *Rhodothamnus*, a phylogenetically old type of the Tertiary. The age of these three monotypic genera is also shown by the fact that they do not exhibit any variation, while *Rhododendron*, *Kalmia* and *Phyllodoce*, genera probably derived from these monotypic genera, have split up into many species, *Rhododendron* being apparently the youngest and most unstable in its specific characters. *Loiseleuria* being an arctic plant has still a wide circumpolar distribution, while *Rhodothamnus* is a relict of the European Alps and *Kalmiopsis* of the higher mountains of Northwest America. The last named is the most restricted, having been found so far only in two or three localities in the Siskiyous, a mountain range which shelters some other interesting local relicts as *Picea Breweriana* S. Wats., a species whose nearest relations are found now in southeastern Europe and Eastern Asia. Also *Quercus Sadleriana* R. Br. Campst. which is restricted to the same region has no close relation in western North America.

Kalmiopsis, gen. nov.

Calyx 5-partitus, persistens, basi gibbosus, segmentis oblongo-ovatis; corolla late campanulata, 5-loba, lobis late ovatis obtusis; stamina 10, corollae subaequilonga, antheris dorsifixis poris apicalibus dehiscentibus, filamentis filiformibus basi leviter dilatatis et ciliolatis; discus tenuis, obscure 10-lobatus; stylus brevis rectus, stigmate capitato leviter lobulato; ovarium hemisphericum, 5-loculare, placentis angulo interiori medio adnatis bilobis multi-ovulatis; capsula subglobosa, crustacea, septicide 5-valva, valvis apice bifidis ab axi placentifero solutis; semina ovoidea, utrinque obtusa, testa firma leviter reticulata.—Frutex parvus, sempervirens, gemmis pauciperulatis, foliis coriaceis breviter petiolatis subtus glanduloso-lepidotis, margine minutissime spinuloso-ciliolatis, floribus in axillis

bractearum in apice ramulorum in racemum congestis, graciliter pedicellatis, pedicellis basi bracteolis persistentibus suffultis, fructu erecto.

Genus monotypicum, proximum *Loiseleuriae* Desv., *Kalmiae* L. et *Rhododendro* L. A primo praecipue differt staminibus 10, antheris poris apicalibus dehiscentibus, ovario 5-loculari, foliis alternis subtus glandulosa-lepidotis; a secundo staminibus ab initio liberis, non antheris in foveolis corollae inclusis, foliis subtus glandulosa-lepidotis; a tertio capsula subglobosa, parietbus tenuibus, valvis apice bifidis, seminibus ovoideis utrinque obtusis, testa firma. Magis distare videtur a *Phyllodoce* Salisb. quae foliis congestis linearibus valde revolutis et corolla ovoidea vel campanulata differt, et a *Rhodothamno* Reichenb. qui floribus leviter zygmorphis, corolla rotata, stylo exserto, foliis longe ciliatis et ut genus pracedens defectu glandularum lepidotarum recedit.

Species unica Americae boreali-occidentalis incola.

Kalmiopsis Leachiana (Henderson), comb. nov.

Rhododendron Leachianum L. F. Henderson in Rhodora, XXXIII. 205 (1931).

Frutex erectus, valde ramosus, 15–25 cm. altus; ramuli annotini puberuli et sparse glandulosi; gemmae parvae, perulis paucis subfoliaceis ciliatis glanduloso-lepidotis. Folia sempervirentia, coriacea, elliptica, elliptico-oblonga vel elliptico-obovata, acuta vel obtusiuscula, rarius rotundata, mucronulata, basi cuneata, margine glabra vel fere glabra vel minutissime setoso-ciliolata, 1–2 cm. longa et 4–8 mm. lata, supra intense viridia, lucida et glabra vel interdum sparsissime glanduloso-lepidota, subtus paullo pallidiora et glandulis lucidis immersis distanter instructa, costa et venis 4–5 supra leviter impressis, subtus costa leviter prominula et venis vix visibilibus; petioli 1 mm. longi, minute puberuli et sparse glandulosi. Flores axillares, solitarii, 3–10 in apice ramulorum racemum umbellatim congestum formantes, flores inferiores in axillis foliorum parvorum apicum versus in bracteas ovato-lanceolatas glandulosas bracteolis paulo tantum longiores decrescentium; pedicelli graciles, 1–1.5 cm. longi, minute glanduloso-puberuli, imo basi bracteolis orbiculari-ovatis mucronulatis minute glanduloso-ciliolatis dorso glanduloso-lepidotis suffulti; calyx fere at basin partitus, lobis oblongo-ovatis vel ovatis 4–5 mm. longis obtusiusculis margine plus minusve glanduloso-ciliatis dorso sparsissime glanduloso-lepidotis vel glabris basi gibbosus et in annulum apicem pedicelli cingentem productus; corolla late campanulata, 10–12 mm. longa et 12–15 mm. lata, rosea, basin versus albescens, lobis late ovatis tubum latum circiter aequantibus margine leviter crenulatis vel undulatis

extus medio sparse glanduloso-lepidotis; stamina 10, corollam subaequantia, 8–10 mm. longa, filamentis glabris ima basi dilatata ciliata excepta, antheris oblongis 2 mm. longis lilacinis; pistillum dimidiam corollam aequans vel eam superans, stylo glabro 3.5 vel 8 mm. longo, stigmate capitato, ovario depresso-globoso dense glandulosa-lepidoto basi disco nudo tenui leviter 10-crenato inclusa excepta. Capsula subglobosa, 4–5 mm. diam., calyce persistente suffulta, seminibus late ellipsoides utrinque obtusis 0.5 mm. longis fuscis minute granulatis.

Oregon: higher Siskiyou Mts., Curry County, *Mr. & Mrs. J. R. Leach*, no. 2915 (in part), June 14, 1930; rocky ground on Horse Sign Butte and along Collier Bar Trail, alt. 2000–4000 ft., Curry County, *Mr. & Mrs. J. R. Leach*, no. 2915 (in part), May and June 1931.—Type in the herbarium of the University of Oregon; isotypes in the herbarium of the Arnold Arboretum and in the Gray Herbarium.

The plants of the three collections show slight variations in several characters. The plants of the collection of 1930 from the higher Siskiyou Mountains have the leaves elliptic to elliptic-oblong, acute or acutish at the apex, and only slightly setulose or glabrous on the margin, the inflorescences are 3–7-flowered and the style is 3.5 mm. long. Of the two collections made in 1931 on Horse Sign Butte and along Collier Bar Trail, the one which bears fruits of the previous season has an inflorescence and leaves similar to the 1930 collection, but the latter are rather densely setulose-ciliolate on the margin; the other collection has slightly shorter leaves elliptic to obovate-elliptic, obtuse or obtusish at the apex and with less densely ciliolate margin, and has generally 2–3- sometimes to 5-flowered inflorescences and the style 8 mm. long, exceeding the corolla. The variations in the length of the style is interesting; it can hardly be explained as heterostyly which is unknown in Ericaceae and must apparently be considered a seminal variation. The question whether this character is concomitant with the shape of the leaves can possibly be solved by making collections with exact indications of the locality of flowering material from all the stations and at the same time paying attention to possible variations of individual plants. Also mature fruit is much needed since we have so far only old disintegrating fruit of the previous year.

It is highly desirable that this little Ericaceous shrub which is not only botanically very interesting, but is also with its attractive rosy-purple flowers a handsome ornamental shrub for the rock garden, should soon be introduced into cultivation, so that this genus may be preserved at least in cultivation if it should become

extinct in its native habitat, which, owing to its limited distribution, seems not impossible.

HERBARIUM, ARNOLD ARBORETUM
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EXPLANATION OF PLATE 40

Fig. 1. Flowering branch from the 1930 collection (natural size).
Figs. 2 and 3. Flowers (magnified).
Fig. 4. Stamen (magnified).
Fig. 5. Longitudinal section of flower from the 1931 collection (magnified).
Fig. 6. Cross-section of ovary (magnified).
Fig. 7. Seed (magnified).
Fig. 8. Under surface of leaf from the 1930 collection (magnified).
Fig. 9. Leaf from flowering branch of the 1931 collection (natural size).

Kalmiopsis Leachiana (Henders.) Rehd.

DIAXYLARY LATICIFEROUS CELLS OF BEAUMONTIA GRANDIFLORA

R. H. Woodworth

Plate 41

Among the specimens taken for anatomical studies from the Harvard Botanical Gardens in Cienfuegos, Cuba, by Dr. R. H. Wetmore and the writer are stems of *Beaumontia grandiflora* Wall., an East Indian member of the Apocynaceae.

When the living stems are cut there is a copious exudation of latex. Stained transverse sections of the stem show a general distribution of latex cells in the phloem and an abundance of these elements in the outer region of the pith. Radial sections of the stem show these laticiferous members to be devoid of cross walls. Figure 2 pictures a meandering latex cell in the pith and figure 5 shows one in the phloem, surrounded by parenchyma. When tissue is differentiating below meristems some of these latex cells apparently work across the procambial region. As this region matures the cells adjacent to the latex cell are affected so that they remain parenchymatous (figures 1 and 4).

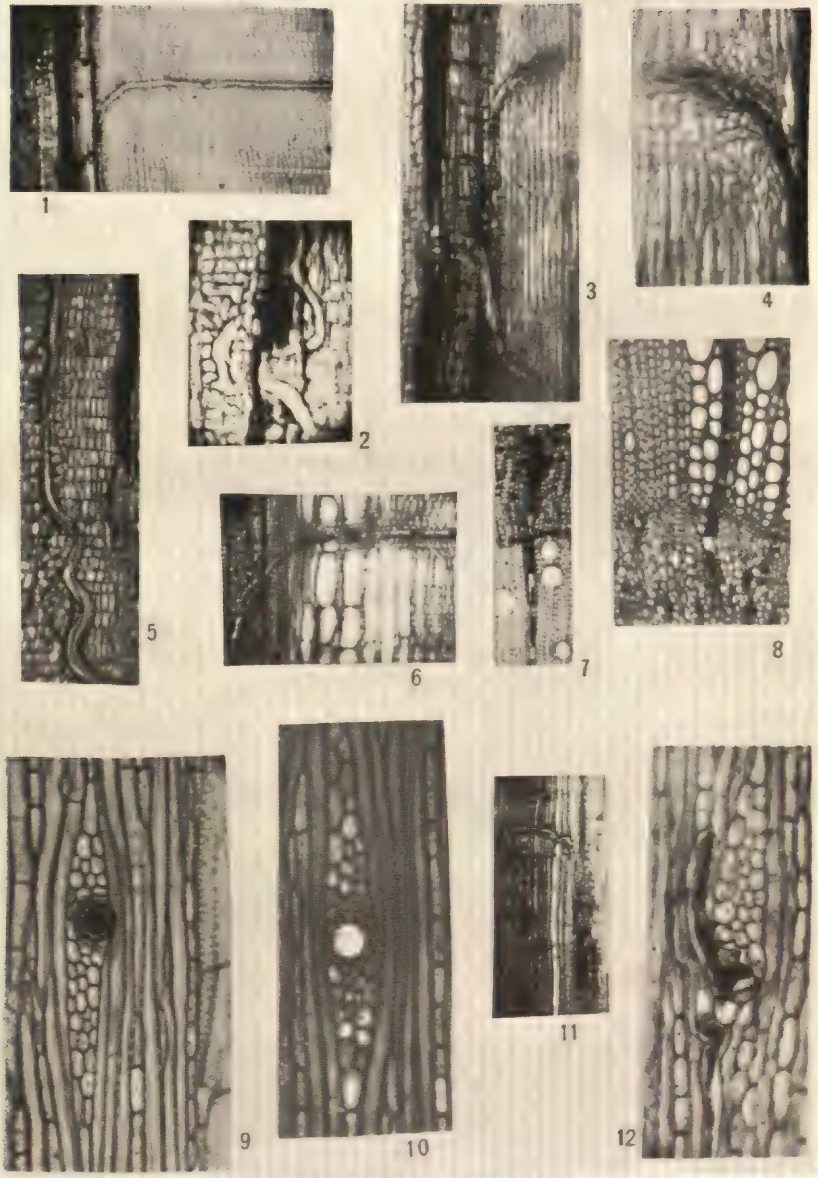
Often the latex cells do not pass from the pith to the xylem at right angles to the vascular elements but rather they swing in an arc for some distance finally settling in a horizontal position in the xylem (figures 1, 3, 4, 6, 11). Figures 1 and 3 picture the pith at the left, then several files of intraxylary phloem cells (sieve tubes with slime plugs), while the remaining tissue is xylem. Occasionally in the transverse section a latex cell is seen extending from the pith into the xylem entirely in the horizontal plane (figure 8, pith is in lower portion of the photograph). Figure 7 shows a similar situation where a latex cell extends from the xylem out into the phloem. As cambial activity increases the size of the stem the latex cell also apparently grows at the cambial region.

It has been mentioned above that parenchyma cells near the latex cell do not differentiate, in fact they make up what is essentially a ray. This is clearly shown in the tangential section through the xylem (figures 9 and 10). Figure 10 depicts the latex cell surrounded by parenchyma while figure 9 shows it in contact with wood fibers on one side. These two conditions appear in about equal proportions.

The fact that these horizontal latex cells accompanied by parenchyma connect with the vertical laticiferous system in the phloem

is brought out in figure 12, which is a tangential section through the phloem. Here the horizontally directed canal similar to those of figures 9 and 10 is seen to be in direct communication with a vertical laticiferous cell.

DEPARTMENT OF BOTANY,
HARVARD UNIVERSITY.



Diaxilary laticiferous cells of Beaumontia grandiflora
(Explanation in the text)

CHROMOSOME NUMBERS AND THE ANATOMY OF THE SECONDARY XYLEM IN THE OLEACEAE

KARL SAX AND ERNST C. ABBE

With two text figures

THE OLEACEAE form a natural family of plants, although there are well marked differences between most of the genera. The family is divided into the Oleoideae which includes *Fraxinus*, *Forsythia*, *Syringa*, *Forestiera*, *Chionanthus*, *Olea*, and *Ligustrum*, and the subfamily Jasminoideae which includes *Jasminum*. According to Rehder there are more than 20 genera with over 400 species, most of which are trees and shrubs.

The natural grouping of these genera is indicated not only by their taxonomic characters but also by their immunological, grafting, and anatomical relationships. Chester (1931) working with *Chionanthus*, *Fraxinus*, *Forsythia*, *Ligustrum* and *Syringa*, found no normal precipitin reactions between these genera.

According to DeCandolle the Lilac can be grafted on Ash, *Chionanthus* and *Fontanesia* while the Persian Lilac grafted on *Phillyrea* survived for ten years. The Olive can also be grafted on *Phillyrea* and *Fraxinus*. *Syringa* is commonly grafted on Ligustrum stock, although as Chester has pointed out, this practice often leads to "graft blight" due to incompatibility between stock and scion. The writer has seen Syringa grafts on *Fraxinus* which made a growth of several feet, but the graft does not survive the second year. These grafts were made by Dr. Johnson in Illinois. Chester found complete incompatibility of grafts between *Syringa* with *Chionanthus* and *Forsythia*. The fact that such morphologically diverse genera as *Syringa* and *Fraxinus* will function together, even for one season, indicates a rather close relationship between these genera.

The Oleaceae are widely distributed and are found in Asia, Europe, and America. Certain genera such as *Fraxinus* and *Chionanthus* are represented in both North America and Asia, while others such as *Syringa*, *Forsythia* and *Ligustrum* are natives of Asia and Europe. One genus, *Forestiera*, is found only in North and South America. The geographic distribution indicates that the family originated in Asia.

The relationships of the genera of Oleaceae would indicate that the chromosome complexes might be similar. Little cytological work has been done on this family. The writer (Sax, 1930) found 23–34 pairs of chromosomes in representative species of *Syringa*,

and Tischler (1930) reports 22 chromosomes for this genus. O'Mara (1930) found 14 pairs of chromosomes in *Forsythia*. The chromosome numbers of other genera available in the Arnold Arboretum have been investigated. The meiotic counts are based on aceto-carmine smear preparations. The writer is indebted to Mr. Dermen for the preparations of *Ligustrum, Olea* and *Jasminum*. Most of the chromosome counts for *Syringa* are based on the writer's earlier study of this group. The haploid chromosome numbers of the species studied are presented in the following table. The counts for *Olea* and *Jasminum* are based on preparations of root tips obtained from plants in the greenhouse.

Oleaceae

Genus		Species	Chromosome No.	Habitat
Fraxinus	Sec. 1.	Bungeana	23	China
		chinensis	69	Asia
	Sec. 2.	americana	23	N. America
		pennsylvanica	23	N. America
		oregona	23	N. America
		excelsior	23	Eu., Asia Minor
Forsythia		suspensa	14	China
		viridissima	14	China
		europaea	14	S. E. Europe
		ovata	14	Korea
Syringa Subgen. 1.				
Ser. 1.		yunnanensis	24–68	China
		Josikaea	23	S. E. Europe
		Sweginzowii	23	China
		villosa	23–24	China
		tomentella	23–24	China
		Komarowi	23	China
Syringa Ser. 2.				
		velutina	23	Asia
		Palibiniana	24	Korea
		pubescens	24	China
		Meyeri	23	China
		oblata Giraldii	23–24	China
		vulgaris (varieties)	23–24	S. E. Europe
		persica laciniata	22	China
		pinnatifolia	24	China
Subgen. 2.				
		amurensis	23	China
Forestiera		japonica	23	Japan
Chionanthus		acuminata	23	N. America
Ligustrum		virginica	23	N. America
		vulgare	23	Eu., N. Afr.
		Quihoui	23	China
		acuminatum	23	Japan

Genus	Species	Chromosome No.	Habitat
	ibota	23	Japan
	acutissimum	23	China
	amurense	23	China
	obtusifolium	23	Japan
Olea			
	europaea	23	S. Europe
Jasminum			
	fruticans	13	Mediterr. Reg.

The basic haploid chromosome number in *Fraxinus* is 23. One of the bivalent chromosomes seems to be conspicuously larger than the others, a situation also found in several other genera of this family. *Fraxinus chinensis* is a hexaploid with about 69 pairs of chromosomes. As shown in figure 2 there is no great amount of secondary pairing of the meiotic chromosomes.

All of the species, varieties and species hybrids of *Forsythia* have 14 pairs of chromosomes (O'Mara). The somatic chromosomes of *F. intermedia* are shown in figure 11. The size and shape of the somatic chromosomes are essentially the same as those of *Syringa* (Sax 1930), *Fraxinus* and *Olea*.

The chromosome number in *Syringa* seems to vary somewhat. Tischler (1930) reports 22 meiotic chromosomes in several species. The writer has found 22 pairs of chromosomes in *S. persica lacinata* (a fertile form from China), but 23 is the number most frequently found in the other species.

In the species hybrid *S. chinensis* (*S. persica* × *S. vulgaris*) there are usually about 24 chromosomes at meiosis but in some cases the number at metaphase may be 36 (fig. 6) or more. In some division figures there seems to be about 12 bivalents and 12 univalents (Sax 1930) which would indicate that one of the parents contributed only 12 chromosomes in this cross. But both *S. vulgaris* and the fertile forms of *S. persica laciniata* have about 23 pairs of chromosomes.

Syringa persica and some of its varieties are also species hybrids as shown by the writer and by Tischler. The chromosome behavior is irregular and the plants are highly sterile. In some cases as many as 44 chromosomes have been counted at meiosis. It is probable that there is weak pairing of the chromosomes in these hybrids so that only univalent chromosomes are sometimes found at meiosis.

The haploid chromosome number is 23 for *Forestiera*, *Chionanthus* and *Ligustrum* (figs. 7, 8 and 9). There are 46 somatic chromosomes in *Olea europaea* which are similar to those of *Syringa* and *Forsythia* in respect to size and shape.

Jasminum has been placed in the subfamily Jasminoideae. The one species studied, *J. fruticans*, has 26 somatic chromosomes. As

TEXT FIGURE 1. CHROMOSOME NUMBERS IN OLEACEAE
(For explanation see p. 47)

shown in Figure 10, the somatic chromosomes are somewhat longer than those of the genera in the first group. The chromosome number and morphology in this genus seems to support the taxonomic grouping of this genus in a second subfamily.

Of the 8 genera studied 6 have 23 chromosomes as the basic number. It is possible that the original basic number was about 12, since *Forsythia* has 14 pairs of chromosomes and *Jasminum* has 13. There is also some evidence that in the species hybrid *S. chinensis* there may be approximately 12 bivalent and 12 univalent chromosomes at meiosis.

In general the genera and species of Oleaceae seem to constitute rather distinct genetic units. The only generic hybrid known is between *Osmanthus* and *Phillyrea* which was mentioned in a recent issue of Gardener's Chronicle (ser. 3, XC. 367. 1931). A few species hybrids are found in *Forsythia*, *Syringa* and *Ligustrum*. Numerous attempts have been made to cross species from different groups of the genus Syringa but without success.

The Oleaceae have been differentiated into rather well marked genera and species and have attained a wide geographic distribution with little change in chromosome number or chromosome morphology.

ANATOMY OF THE SECONDARY XYLEM

Before discussing the groups into which the genera under consideration naturally fall, it might be well to give a short description of each genus. The genera[1] studied are described in the order in which they are represented in Figure 2, (p. 46) reading up.

The material of *Jasminum*[2] available being only one year old, the conclusions based on it later are presented as being only tentative. The rays are uniformly uniseriate, and are composed of vertically elongate cells. Köhl (1881 p. 6) states that in more mature material they are rarely biseriate, and generally composed of vertically elongate or isodiametric cells (*J. revolutum*) only. The segments of the thin-walled, angular vessels have acute and porous end walls and gradually decrease in diameter in the course of the season's growth, so that a simple type of ring-porosity obtains. Parenchyma is both terminal and associated with the vessels. The tracheid walls are of medium thickness with rather large bordered pits whose orifices are not as long as the diameter of the pit membrane. Tertiary spiral thickening of the walls is present in both vessels and tracheids.

Forsythia,[3] as well as the remaining genera, commonly has both

[1] The junior author had access to Professor I. W. Bailey's collection of slides, augmented by material kindly supplied by Alfred Rehder and Professor Record.

[2] Represented by *J. heterophyllum* Roxb. and *J. Giraldii* Diels.

[3] Represented by *F. suspensa* Vahl, and *F. viridissima* Lindl.

multiseriate and uniseriate rays. The multiseriates in this genus are commonly two cells wide, and have uniseriate extensions which are longer than those in the other genera studied. The marginal cells are tall, although often also isodiametric in the radical plane. In arrangement the vessels are diffuse or weakly ring-porous and are mostly solitary. less often in radial groups of two or three, rarely in larger radial groups. In structure the vessel segments are thin-walled, angular, elongate, with acute end walls which are occasionally scalariform or tend to retain vestiges of bars when porous. The parenchyma occurs as isolated cells between the vessels, directly associated with the vessels, and also terminal. The tracheid walls are of medium thickness and have large bordered pits with short diagonal orifices. Both vessels and tracheids have spiral tertiary thickening.

The uniseriate rays in *Syringa*[1] are generally accompanied by biseriate rays although triseriates occur commonly in *S. Julianae* and *S. yunnanensis*. Uniseriate extensions may occur in the *Vulgares* group but are practically absent in the other two groups. The marginals are usually isodiametric in the radial plane, with a tendency towards their being vertically elongate in the species which have the longer uniseriate extensions. In the *Ligustrinae*, on the other hand, horizontally elongate marginals are more common. The vessel segments are elongate, thin-walled, angular with acute to obtuse end walls which are generally porous, although Solereder (1885, p. 171) reports having found scalariform end walls with a single bar in *S. vulgaris*.

Although the bulk of the species are ring-porous and have spiral thickenings in the tracheids and vessels, the members of the *Ligustrinae* have diffuse vessel arrangement, only very weak spiral thickening, and, in addition, have tyloses in the vessels.

The walls of the spring tracheids range from rather thin to medium thick, while in the summer wood they are medium thick to thick. The pits are bordered and have elongate, diagonal orifices which are as long or somewhat longer than the diameter of the pit membrane.

Both uniseriate and biseriate or triseriate rays are present in *Ligustrum*,[2] but uniseriate extensions are seldom present and are very short when they do occur. The marginal cells vary from isodiametric to vertically elongate. The angular, thin-walled vessels

[1] Represented in subgen. *Eusyringa* group *Villosae* by *S. yunnanensis* Franch., *S. villosa* Vahl; in *Eusyringa* group *Vulgares* by *S. Julianae* Schneid., *S. microphylla* Diels, *S. persica* L., *S. pinnatifolia* Hemsl., *S. pubescens* Turcz., *S. velutina* Komar.; in subgen. *Ligustrina* by *S. amurensis* Rupr., *S. japonica* Decne., *S. pekinensis* Rupr.

[2] Represented by *L. kiyozumianum* Nakai, *L. sinense* Lour., *L. vulgare* L.

have elongate segments with acute to obtuse, porous end walls. They are ring-porous in arrangement, most commonly occurring alone or in radial groups of two or three, or in long radial or diagonal rows (*L. sinense*).

The parenchyma is sparse and is only terminal or next to vessels.

The tracheids are medium to thick-walled and have bordered pits with orifices about as long or longer than the diameter of the pit membrane.

Associated with the uniseriate rays in *Chionanthus*[1] are bi-, tri-, and rarely 4- or 5-seriate rays which ordinarily completely lack uniseriate extensions, but may have short ones. The marginals are isodiametric or even horizontally elongate in the radial plane. The vessel segments are elongate, thin-walled, angular, and have acute end walls which are porous. The vessels occur in diagonal groups, forming "flames," the component vessels decreasing in size in the course of the year's growth. The wood parenchyma is terminal and also associated with the vessels. Tracheids are not very thick-walled and have bordered pits with elongate diagonal orifices about the width of the pit membrane.

The ray condition in *Fraxinus*[2] is quite variable but is predominantly fusiform associated with occasional uniseriates. The multiseriates in some cases (*F. Sieboldiana, F. Biltmoreana, F. caroliniana, F. oregona, F. mandschurica*) may have an occasional very short uniseriate extension. The multiseriate rays generally far outbalance the uniseriates in number but *F. caroliniana* is a notable exception in this respect. The marginal cells are ordinarily horizontally elongate with a strong tendency especially in the *Melioides* toward the isodiametric type.

The vessel segments are of two types, the thick-walled, elongate ones of small diameter with obtuse to acute porous end walls, and the thin-walled, depressed segments with transverse porous end walls, relatively great diameter (4 or 5 × that of the later summer wood vessels). Both types occur singly or in radial pairs or groups of 3 or 4. The thick-walled vessels characterize the summer wood, and the thin-walled ones the spring wood. There is ordinarily a very rapid transition from the spring to the summer type of vessel resulting in a very definite ring-porous condition.

The parenchyma occurs both with the vessels and terminally,

[1] Represented by *C. virginica* L.

[2] Represented in § Ornus by *F. pubinervis* Bge., *F. chinensis* Roxb. var. *rhynchophylla* Hemsl., *F. floribunda* Wall., *F. Sieboldiana* Blume; in § *Fraxinaster* by *F. americana* L., *F. Biltmoreana* Beadle, *F. oregona* Nutt., *F. carolinana* Mill., *F. pennsylvanica* Marsh.; in § Melioides by *F. mandschurica* Rupr., *F. quadrangulata* Michx., *F. nigra* Marsh.

with a strong tendency toward the formation of tangential bands in the summer wood.

The tracheids are thin-walled in the spring wood and thicker in the summer wood, having in both cases bordered pits with orifices as long as or longer (much longer in the summer wood) than the diameter of the pit membrane.

Tyloses generally fill the lumens of the vessels.

Forestiera[1] has both uniseriate and biseriate rays, the biseriate rays sometimes often lacking uniseriate extensions which do not average as long as in *Forsythia*. The marginal cells are much more rarely vertically elongate than in *Forsythia*, tending more commonly to be isodiametric in the radial plane of section. The vessels are diffuse in arrangement, occurring singly, or in pairs, less commonly in radial groups of three or rarely four. The rather thick-walled vessel segments are elongate with obtuse, porous end walls. Parenchyma is terminal and also associated with the vessels with a tendency toward tangential groups in *F. rhamnifolia* and well developed tangential rows in *F. porulosa*. The pitting of the rather thick-walled tracheids is typically bordered with the mouth of the pit varying in size from slightly less than to several times the diameter of the pit membrane.

In *Olea*[2] the multiseriate rays vary from bi- to triseriate, and are always associated with small uniseriates. Except in *O. europaea* which often has fairly long uniseriate extensions on the rays, they are fusiform. The marginal cells range from slightly elongate vertically to isodiametric in *O. europaea*, but in the other species they are more commonly isodiametric to horizontally elongate. The elongate, rather thick-walled vessel segments with porous and obtuse end walls, occur singly or in groups of several to many. These groups are simply radial rows in *O. europaea*, but in the other two species they tend to be in "flames." Parenchyma is in tangential bands in *O. Cunninghamii* and *O. verrucosa* as well as being associated with the vessels in the "flames." In *O. europaea*, however, it is simply terminal and beside the vessels. Tracheids are very thick-walled and the pit mouths are very elongate or simply porous.

The above descriptions are summarized and generalized in a diagrammatic form in Fig. 1.

Jasminum with its uniseriate or rarely biseriate rays composed of vertically elongate cells stands well apart from the other genera studied which uniformly have very well developed multiseriate as well as uniseriate rays. The tracheid-like vessel segments of *Jas-*

[1] Represented by *F. acuminata* Poir., *F. neo-mexicana* Gray, *F. porulosa* Poir., and *F. rhamnifolia* Griseb.

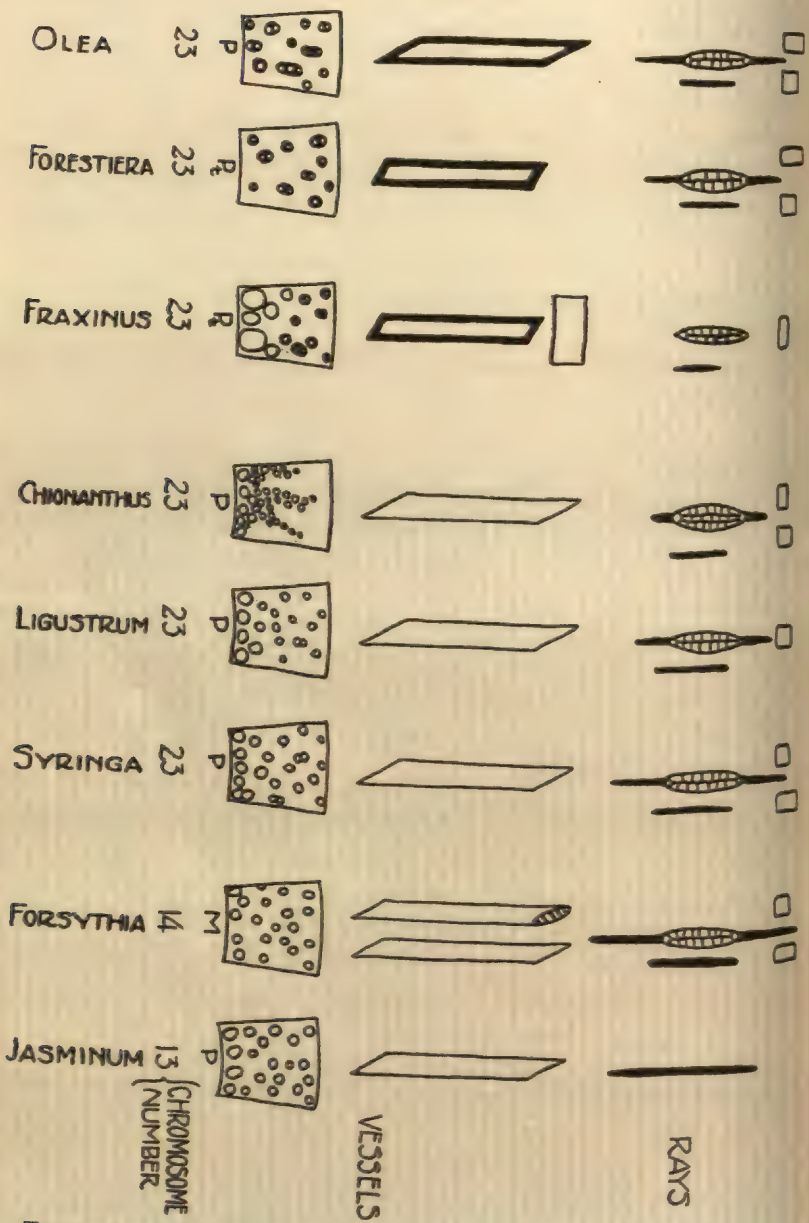
[2] Represented by *O. europaea* L., *O. Cunninghamii* Hook., and *O. verrucosa* Link.

minum also distinguish it. In both rays and vessel structure *Forsythia* approaches *Jasminum* more closely than do any other genera of the Oleideae. On the other hand, *Forsythia* differs in such important respects as type of parenchyma distribution, the occasional occurrence of vessel segments with scalariform end walls, and ring porous vessel distribution. Nevertheless, the anatomical structure of *Jasminum* is closer to that of *Forsythia* than that of the other genera, a conclusion also reached by Kohl (1881). That the chromosome numbers of the two is so close is very suggestive, although there is not a complete parallelism because morphologically *Forsythia* seems to approach *Syringa* more nearly than it does *Jasminum*.

In the Oleoideae, *Forsythia* resembles in its diffuse vessel distribution the members of the Ligustrinae in *Syringa*. The reported occurrence of weakly scalariform end walls in *Syringa* strengthens this similarity. Although similar to *Syringa* in these respects it differs in type of parenchyma distribution, and has much longer uniseriate extensions on the multiseriate rays. Thus, although showing many points of similarity to *Syringa*, *Forsythia* is distinguished by the rather commoner occurrence of a decadent scalariform type of end wall, parenchyma between the vessels, and diffuse vessel distribution. That the chromosome number of *Forsythia* is different from that of all the other Oleoideae is of interest, considered in connection with its grafting incompatibility with other genera of this subfamily.

Although *Syringa* has several tendencies in common with *Forsythia*, it shows much closer similarity to *Ligustrum* which in turn is quite close in structure to *Chionanthus*. This grouping is significant because although DeCandolle states that Lilac can be grafted on *Chionanthus*, Chester finds incompatibility of such grafts after the first year. The vessels are of the same type in the three genera, the chief variation being found in vessel arrangement which varies in *Syringa* from diffuse to ring-porous, is ring-porous in *Ligustrum*, and in "flames" in *Chionanthus*. Associated with reduction of length is the decreased occurrence of uniseriate extensions of the multiseriate rays, as well as a tendency toward horizontally rather than vertically elongate marginal cells. Although *Chionanthus* and *Syringa* stand at opposite ends of this range variation, it is so continuous that they appear to be components of the same complex.

Another natural group is formed by *Olea europaea* and *Forestiera*, with their thick-walled, unevenly thickened vessels which tend to occur uniformly in distinctive groups of two or three throughout



TEXT FIGURE 2. ANATOMY OF THE SECONDARY XYLEM IN OLEACEAE
(For explanation see p. 48)

the growth ring. The rays, as well as the parenchyma, are essentially of the Ligustrum type, although in the parenchyma there is a tendency toward the formation of tangential rows.

Fraxinus stands very much alone, although it has characters suggesting each of the two previous groups. In the ray type and the ring-porous condition it strongly suggests the Syringa-Ligustrum-Chionanthus complex. In parenchyma, and vessel distribution in the summer wood, it resembles the Olea-Forestiera group. And making it quite distinct from either group is the occurrence in the spring wood of the very large, thin-walled vessel segments with their transverse, porous end walls. In its chromosome number and morphology it is the same as the other two groups, and by its grafting relationships it shows an affinity for each group.

On the whole there is a suggestive parallelism between chromosome number, grafting relationships and anatomical structure.

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DESCRIPTION OF FIG. 1

The meiotic figures are from aceto-carmine mounts. Magnification 2000 ×. The somatic chromosomes from root tip preparations are magnified 4000 ×.

1. Fraxinus excelsior. 1 M. 23 chromosomes.
2. Fraxinus chinensis rhynchophylla. 1 M. 69 chromosomes.
3. Fraxinus pennsylvanica. 1 M. 23 chromosomes.
4. Syringa vulgaris var. 1 M. 24 chromosomes.
5. Syringa persica laciniata. 1 M. 22 chromosomes.
6. Syringa chinensis Saugeana. 1 M. 36 chromosomes of which about 12 are univalents.
7. Foresteria acuminata. 1 M. 23 chromosomes.
8. Chionanthus virginica. 1 M. 23 chromosomes.
9. Ligustrum amurensis. 1 M. 23 chromosomes.

10. Jasminum fruticans. 26 somatic chromosomes.
11. Forsythia intermedia. 28 somatic chromosomes.
12. Olea europaea. 46 somatic chromosomes.

DESCRIPTION OF FIG. 2

Diagrammatic comparison of the wood structure of the genera examined. M = parenchyma between the vessels and associated with the vessels as well as terminal; P = parenchyma terminal and associated with the vessels; Pt = parenchyma terminal and associated with the vessels and forming tangential rows in the summer wood. The rectangles on the right hand side of each multiseriate ray indicate the aspect of the marginal cells in the radical plane. Uniseriate rays and uniseriate extensions of multiseriate rays are indicated in solid black.

CHROMOSOME NUMBERS IN THE GENUS TILIA

HAIG DERMEN

With text figures

THE FAMILY Tiliaceae contains about 35 genera and some 400 species (Rehder, 1927). The genus *Tilia* is the only member of the family which is found widely distributed in the north temperate zone, while of the genus *Grewia* only *G. biloba* G. Don extends north as far as northern China.

The fossils that have been recorded are limited to ancestral forms of *Tilia* according to Berry (1923) which have been discovered in the northern hemisphere in early and late tertiary formations. These fossils have been found in Spitzbergen, Alaska, Saghalin Island and in Montana, which would indicate that Tilia stock originated somewhere in the far north.

From the Arnold Arboretum plants of ten species and five varieties of *Tilia* and one species of *Grewia* were studied and their chromosome numbers determined. Meiotic figures were drawn from aceto-carmin smear preparations from buds, and somatic chromosomes from root-tip sections. The chromosome numbers of *Tilia* plants were determined from buds and in one case also from root-tips. The number of chromosomes in *Tilia* was n = 41 (Fig. 1), making this the highest odd basic number for a genus in plants so far recorded in the published chromosome lists of Tischler (1931) and Gaiser (1930). Eleven plants were diploid forms and four tetraploid forms with n = 82 chromosomes. The diploid forms are: *Tilia cordata, T. cord. cordifolia, T. glabra, T. neglecta, T. Oliveri, T. petiolaris, T. platyphyllos laciniata, T. plat. vitifolia, T. plat.* var. (Fig. 2), *T. vulgaris* (Fig. 1), *T. vulgaris pallida.* The tetraploid forms are: *Tilia amurensis, T. insularis, T. Maximowicziana* and *T. tuan.*

A single species of the related genus *Grewia* was studied from bud and root-tip preparations to see if it was cytologially related to *Tilia.* The only relationship found was one of size, both *Tilia* and *Grewia* having very small chromosomes, measuring about 1 micron in length and ½ micron in thickness (Figs. 2 and 4). In this species, *G. biloba* G. Don (*G. parviflora* Bge.) the number was n = 9 (Fig. 3).

If the Tiliaceae originated from forms with such a low basic number of chromosomes, the number found in *Tilia* must have been derived by both duplication and fragmentation of chromosomes of the basic complex. The possibility of fragmentation is shown in

Grewia where frequently segments are so loosely joined as to be mistaken for whole chromosomes (Fig. 4). Therefore it is suggested that in the case of *Tilia* some of these segments may have been actually broken off and perpetuated as individual chromosomes. The same difficulty was encountered in counting and drawing chromosomes of *Tilia* from root-tip sections where sometimes the number appeared to be 84 instead of 82, though the number of both genera was definitely determined as n = 41 for *Tilia* and n = 9 for *Grewia*.

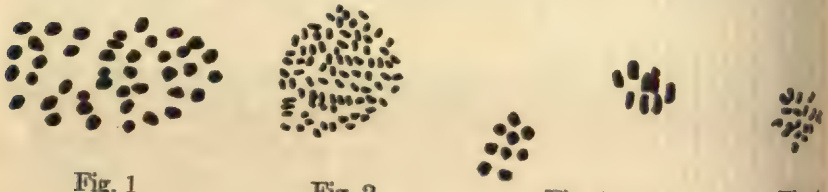

Fig. 1 Fig. 2 Fig. 3 Fig. 4

(Explanation in the text)

Some pollen grain measurements were made and practically no difference in size was found between diploid and tetraploid species. *Grewia* with only n = 9 chromosomes had pollen grains which were equal to or larger than those of *Tilia*.

Gaiser (1930) lists a number of species from related families of Tiliaceae. The original references were studied to find out whether these species showed any cytological relationship to *Tilia* or *Grewia*.

In the Malvaceae family *Malva moschata* (n = ?), *Lavatera thuringiaca* (n = 20?), *Althaea sulphurea* (n = ?), *Malvastrum capense* (n = 21), *Sidalcea neo-mexicana* (n = 13), and of the Tiliaceae family, *Entelea palmata* (n = 8) and *Sparmannia africana* (n = 82) had practically the same size of chromosomes as *Tilia*. In the tribe Hibisceae of the Malvaceae family, *Hibiscus tricuspis* (n = 40?), *H. tiliaceus* (n = 48?) and *Gossypium barbadense* (n = 8, 13, 26) chromosomes are somewhat larger, while in *Hibiscus rosa-sinensis* (n = 72?) they are slightly smaller as compared with Tilia chromosomes. The only species, *Theobroma cacao* (n = 8), from the family Sterculiaceae has chromosomes of the same size as in *Tilia*. The only striking diversity was found in the size of *Thespesia populnea* (n = 8, 10, 13) chromosomes, which are shown to be several times larger than any of the above named species.

If size of chromosomes can be considered of any importance in the relationship of plants certainly these genera from allied families of the Malvales order seem to indicate that they are cytologically related to one another, the only striking exception being *Thespesia populnea* with very large chromosomes. A case similar to this was

found in my studies of the genus *Verbena* of the Verbenaceae family (unpublished data). Here the genus was divided into two distinct groups, one with a basic number n = 5 chromosomes and one with n = 7, the latter group having chromosomes about 1/10 the size of the former.

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STUDIES ON THE PRECIPITIN REACTION IN PLANTS

I. THE SPECIFICITY OF THE NORMAL PRECIPITIN REACTION

KENNETH S. CHESTER

Plate 42

INTRODUCTION

THE APPLICATION of the theories and methods of animal immunology to plant pathology has been a subject which up to the present has received very little attention. In large part the failure of pathologists to attack their problems from the standpoint of acquired immunity lies in the theoretical and technical obstacles inherent in a biochemical study of plant disease. Such obstacles are due in part to the differences in structure and development between plants and animals, and in part to differences in the type of infection customarily produced. Thus in plants one is dealing with organisms of indeterminate growth in comparison to the determinate growth of the higher animals, there is no circulatory system in plants closely comparable to the blood system of vertebrates, and finally the majority of plant infections are more strictly localized than are many of the animal infections.

Nevertheless, bearing in mind the close ultimate physiological relationship between the plant and the animal cell, their presumably common origin, and their essential functional similarity, it would indeed be strange to find the plant cell reacting to infections in a manner wholly distinct from that of animal cells. The work reported in the present paper was undertaken in an attempt to throw some light upon the question of the reactions of the plant cell in the presence of foreign protoplasm or its constituents, and is a continuation of the writer's previously reported studies of the precipitin reaction in plants (2).

The precipitin reaction has long been an essential technique of animal immunology. Briefly the theory of the reaction is as follows. A foreign protein is injected into the blood of a mammal. As the result of such sensitization, the injected animal acquires an immunity to the specific protein employed. After a short period of time during which the acquirement of immunity has been in progress, blood is withdrawn from the immunized animal, clarified, and pipetted against a solution of the protein originally used for injection. The immune blood now induces a precipitation of the foreign protein from solution, although the precipitating action is absent in the blood of non-immunized animals. The precipitin

reaction is specific against the protein originally employed but is weak or negative against other foreign proteins. In addition to such acquired precipitating power, mammalian blood frequently possesses the ability to precipitate certain proteins with which it has never been sensitized. The substances or properties in the blood which induce such precipitation of foreign proteins with which the animal has been previously sensitized may be called *acquired precipitins*, whereas the substances or properties of the blood inducing the precipitation of proteins against which the animal has not been immunized are called *normal precipitins*.

The present paper reports a study of the normal precipitins in a number of families of woody plants. Its purposes are fourfold, namely, to determine whether in extracts of woody plants one may obtain phenomena comparable to the reactions of mammalian blood in the presence of foreign proteins, to discover whether such reactions are in any manner correlated with the systematic relationships of the plants studied, to aid in the interpretation of the earlier published data upon the precipitin reaction in plants, and finally to clarify to some extent our conception of the nature of the precipitin reaction in plants and its bearing on the processes of plant immunity.

HISTORICAL

The precipitin technique was first applied to plants by Kostoff in 1928 and 1929 (3, 4). The latter, working with a number of species of the solanaceae, observed that in numerous combinations of extracts of Solanaceous species positive reactions were obtained, whereas negative normal precipitin reactions resulted from other extract combinations. The alphabetical order in which Kostoff arranged his tables of reactions does not bring out well the significance of the reactions which he obtained, nor did he attempt to analyze them in the light of possible correlation with systematic position. A rearrangement of Kostoff's data is given in Table 6 for comparison with the results of the present study. From the standpoint of plant immunology this first paper makes a number of important contributions. The author found that after grafting two species of Solanaceae the precipitin reaction of the extracts of the intergrafted plants was markedly increased, that the increase in precipitin potency was strongest in the tissues nearest the graft union and weakened progressively with increasing distance from the graft union, and that the precipitin potency increased from the time of grafting for thirty or forty days, after which time it reached an equilibrium. In addition to the increased precipitin reaction after grafting, Kostoff also observed certain cytological changes,

all of which were interpreted in terms of an acquired immunity as the result of sensitization by the foreign protein of the graft biont.

The only other study of the precipitin reaction in plants following the technique of direct testing of plant against plant is reported by Chester in 1931 (2). In this paper are considered the results of about a thousand tests in the Oleaceae. No normal precipitins were reported among the species used, but a very strong acquired precipitin reaction was obtained in *Syringa vulgaris* hybrids grafted upon *Ligustrum* species as tested against various oleaceous species. The grafted plants were displaying symptoms of disease due to an incompatibility between the lilac scion and the privet stock, and it was found that the morbid processes resulting from such incompatibility so profoundly modified the components of the lilac extract as to alter markedly the precipitin reaction. The morbidity resulting in this case from graft incompatibility was closely resembled by a morbidity from other causes, and in either case there was a marked increase of precipitin potency accompanying the appearance of morbid symptoms in the leaf.

Brief mention should be made of two other bodies of experimentation somewhat related to the work at hand. Mez and his colleagues have published extensive work dealing with an application of the precipitin reaction in animals to plant materials. The results are the basis of the Königsberg phylogenetic tree. The work of Mez and his collaborators has been published in numerous papers in Botanisches Archiv, to which the reader is referred for a complete account of the Königsberg studies. The theory of Mez' work is fundamentally different from that of the work of Kostoff and Chester, and hence need be considered no further at this time beyond remarking that the reactions obtained are the reactions of an animal injected with plant proteins and do not represent immunological reactions in which the plant is the organism acquiring an immunity.

A second body of plant immunological research deals with experiments apart from precipitin testing to determine the presence of an acquired immunity in plants subjected to disease. An excellent account of the studies on such acquired immunity in plants is to be found in the recent monograph of Carbone and Arnaudi (1). It may be said in passing that although there have been numerous conflicting reports concerning the acquirement of immunity by plants, there are a number of experiments reported by various French and Italian workers which appear to point definitely to such an acquired immunity. The paper of Carbone and Arnaudi gives a full account of these experiments, and a fairly complete bibliography of the work on acquired immunity in plants.

TECHNIQUE

In the summer of 1931, at the suggestion of Dr. Karl Sax, a set of experiments was undertaken to determine the relationships among the genera of the Pomoideae as indicated by the normal precipitin reaction. The results proved so suggestive that other subfamilies of the Rosaceae and other families of the woody plants were eventually tested to the same end. In all about five hundred reactions were performed, involving twelve genera of the Pomoideae, four genera of the Prunoideae, fifteen species of the genus *Prunus*, two other genera of the Rosaceae, nine genera of the Caprifoliaceae, eight genera of the woody Saxifragaceae, and one genus each of the Leguminosae and the Platanaceae. Except as indicated below all the experiments were performed under uniform conditions, with extracts of the same concentration, tested in the same manner, and with the employment of numerous controls. The technique has been fully described in an earlier paper (2) and only brief mention will be made of it here beyond pointing out the modifications which have been developed.

Fresh leaves of the plants to be tested were collected, weighed, washed in tap water and distilled water, dried, and ground to a fine paste in an unglazed porcelain mortar. To the paste thus obtained was added the required amount of distilled water (four times the weight of the leaves in all the experiments below) and the mixtures were placed in an electric refrigerator at 2° C for twenty-four hours. At the end of this time each mixture was filtered until crystal clear through progressively finer filters, and finally placed in an ice bath. Two to four tenths of a cubic centimeter of the liquid of greater specific gravity was next introduced into a specially-made small test-tube by means of a capillary pipette, and the second extract to be tested was pipetted above so as to form a refractive zone between the two. Readings of the reaction were taken at intervals of one, five, ten, twenty, thirty, and forty minutes, and in most of the experiments reported below readings were independently made by two observers. The utmost care was taken at every step to avoid contamination, and all instruments and glassware were cleaned with a sulphuric acid-potassium bichromate mixture for twenty-four hours followed by repeated washings in water.

The positive tests were strong and well marked. In comparison with the results earlier obtained it may be said that all the readings are minimal. There might have been justification for calling some of the plus two reactions plus three or even plus four, but an attempt was made to increase the significance of the results by using

extreme caution in not overestimating the readings. A study of Plate 42 will indicate the scale employed. Figure 1 represents a negative reaction. The delimitation of the two liquids in the tube is clearly indicated, but there is no trace of a white precipitate at the zone of contact. In Figure 2 is seen a reaction indicated in the tables as a "trace" (t). Figures 3 and 4 illustrate plus one reactions, in Figure 3 the precipitate representing the ultimate intensity of the reaction between the two extracts employed while in Figure 4 the plus one reaction illustrated being merely an early stage of a reaction which after some minutes would have increased to plus two or greater. Figures 5 and 6 represent plus two reactions, Figure 6 being a later stage of the same reaction as pictured in Figure 4. Figures 5 and 6 show well the penetration of the precipitate into the lower extract in little white tortuous rootlets. Later stages of these reactions would show only a uniform cloudiness of the lower extract finally extending upward and involving all the liquid in the tube.

The only essential modification of technique that has been made in the experiments herein reported as compared with the earlier precipitin testing in plants has been that a weaker concentration of extract has been used. Heretofore the ratio of plant tissue to distilled water has been 1:2, while for the purposes of the experiments in the present paper a dilution of 1:4 was found more satisfactory. This change was made necessary by the greater percentage of water in the tissues of the plants earlier studied.

One notable advance in technique, however, has been made. There would be a number of distinct advantages if it were possible to use dried leaf tissues in place of fresh tissues. That it might be possible to obtain comparable results using dried leaves was suggested by Osborne and Wakeman's statement that spinach leaves dried at low temperatures and extracted with ether, alcohol, water, and alkaline solutions yielded results so similar, in analysis and protein extraction, that evidently the constituents of the cells are altered to only a slight degree by drying (5).

In order to test out the possibility of using dried leaves in the precipitin tests, the following experiment was performed. From the results obtained in earlier experiments three plants were so chosen that their inter-reactions would include both positive and negative results. For this purpose *Platanus acerifolia*, *Robinia fertilis*, and *Prunus Armeniaca* var. "Mikado" were arbitrarily chosen. Using fresh leaf preparations, the *Prunus* tests strongly against both the *Robinia* and the *Platanus*, whereas the latter two are negative when tested together. Leaves of these three species were collected and

dried in a Riker plant press for two weeks at a temperature of about 30° C. At the end of this time the leaves were brittle and quite dry. Half of the leaves of each species were then placed in an oven at 60° C for twenty-four hours. Finally each of the six lots of leaves thus dried was ground, extracted, filtered, and tested against the other five extracts. The results were wholly satisfactory. Strong reactions were obtained between the Prunus extracts and those of the other species in every case, while the Platanus and Robinia extracts remained negative to each other. The results of this experiment are shown in Table 1.

TABLE 1. A STUDY OF THE EFFECT ON THE PRECIPITIN REACTION OF THE PREVIOUS DRYING OF THE PLANT TISSUES EMPLOYED

Explanation in the text.

	Platanus (Fresh leaves)	Platanus (Air dried)	Platanus (Oven dried)	Robinia (Fresh leaves)	Robinia (Air dried)	Robinia (Oven dried)	Prunus (Fresh leaves)	Prunus (Air dried)	Prunus (Oven dried)
Platanus acerifolia (Fresh leaves)	–			–			3		
Platanus acerifolia (Air dried leaves)		–	–		–	–		3	3
Platanus acerifolia (Oven-dried leaves)		–	–		–	–		2	2
Robinia fertilis (Fresh leaves)	–			–			3		
Robina fertilis (Air dried leaves)		–	–		–	–		2	2
Robinia fertilis (Oven dried leaves)		–	–		–	–		2	2
Prunus Armeniaca (Fresh leaves)	3			3			–		
Prunus Armeniaca (Air dried leaves)		3	2		2	2		–	–
Prunus Armeniaca (Oven dried leaves)		3	2		2	2		–	–

It will be seen that there is a slightly higher reaction accompanying the use of air dried leaves in one case, and although the distinction was too fine to be indicated by the difference of a plus sign, it should be noted that the extracts from air dried leaves always tested slightly more strongly than those from the oven-dried leaves. The reactions as a whole were slightly weaker than those where fresh leaves were used, but the difference is not considered significant. It was impossible to equalize the concentration of the two types of extract with certainty, since the percentage of water in the fresh leaves was not known. In the case of the fresh leaves the weight ratio of leaf tissue to water of extraction was as 1 : 4, while with the dried leaves the corresponding ratio selected was 1 : 10.

The ability to utilize dried leaves in precipitin testing has, as has been indicated, a number of advantages. It is thus possible to continue work with the deciduous woody plants throughout the winter; moreover one may work with specimens shipped in a dried condition from all parts of the globe; it is possible to employ dried herbarium specimens in testing; manipulation of dried material is much easier than of fresh leaves with especial respect to grinding; the extracts made with dried leaves filter much more readily than those made with fresh leaves; and finally adjustment of the water concentration of the extracts may be made with much greater accuracy. The fact that experiments may be performed with essentially the same results whether one uses dried or fresh leaves does not argue against the hypothesis of the protein nature of the reaction according to the evidence of Osborne and Wakeman as cited above.

EXPERIMENTAL DATA

The actual experimental results are shown in the following tables (Tables 2–6). With them is included for comparison a synopsis of the results obtained by Kostoff on the Solanaceae, rearranged according to the systematic position of the genera.

READING AND INTERPRETATION OF EXPERIMENTAL DATA

A word of interpretation is a necessary preliminary to a study of the tables. In contrast to the work of Mez and others, an increasing positive reaction here indicates an increasing degree of divergence from the type. The negative reaction (–) appears to have a double significance. A study of Table 2 will bring this out. In the upper left-hand corner there is a block of negative reactions indicative of the homogeneity of the Pomoideae. Traces of reactions appear in a few instances, but for the main part the results are uniformly

TABLE 2. NORMAL PRECIPITIN REACTIONS IN THE POMOIDEAE AND RELATED GENERA

Explanation in the text.

	Spiraea virginiana	Cotoneaster acutifolia	Mespilus germanica	Pyracantha coccinea	Crataegus punctata	Sorbus Aucuparia	Aronia melanocarpa	Photinia villosa	Stranvaesia Davidiana	Chaenomeles lagenaria	Malus prunifolia	Malus Tschonoskii	Pyrus nivalis	Amelanchier oblongifolia	Rosa rugosa	Prunus Armeniaca	Platanus acerifolia	Robinia fertilis	Philadelphus grandiflorus
Spiraea virginiana	–			–	–			t			–	–			1	2	t	t	t
Cotoneaster acutifolia		–	–	t	–	–	t	t	t	–	t		–	t					
Mespilus germanica		–	–	–	2	–	–	–	–	–	–		–	1					
Pyracantha coccinea	–	t	–	–	–	–	–	–	–	t	–	t	–	–	2	2	–	–	–
Crataegus punctata	–	–	2	–	–	–	–	–	–	–	–	–	–	–	t	t	t	t	t
Sorbus Aucuparia		–	–	–	–	–	–	–	–	–	–		–	–					
Aronia melanocarpa		t	–	–	–	–	–	–	–	–	–		–	–					
Photinia villosa	t	t	–	–	–	–	–	–	–	–	–	t	–	–	1	2	–	–	–
Stranvaesia Davidiana		t	–	–	–	–	–	–	–	–	–		–	–					
Chaenomeles lagenaria		–	–	t	–	–	–	–	–	–	t		–	–					
Malus prunifolia	–	t	–	–	–	–	–	–	–	t	–	t	–	–	2	2	–	–	–
Malus Tschonoskii	–			t	–			t			t	–			–	2	t	–	–
Pyrus nivalis		–	–	–	–	–	–	–	–	–	–		–	–					
Amelanchier oblongifolia		t	1	–	–	–	–	–	–	–	–		–	–					
Rosa rugosa	1			2	t			1			2	–			–	2	2	1	2
Prunus Armeniaca	2			2	t			2			2	2			2	–	3	3	3
Platanus acerifolia	t			–	t			–			–	t			2	3	–	–	–
Robinia fertilis	t			–	t			–			–	–			1	3	–	–	–
Philadelphus grandiflorus	t			–	t			–			–	–			2	3	–	–	–

2 from grafted plants!

negative. The reaction steadily increases as one passes farther from the Pomoideae, beginning with *Spiraea* which is very closely allied to the Pomoideae, passing to Rosa which is somewhat more distantly related to the Pomoideae, and finally reaching *Prunus* with the strongest reaction of all, as might well be expected since of all the subfamilies of the Rosaceae the Prunoideae are farthest removed from the Pomoideae. As we pass outside the family, however, the reaction again diminishes. This phenomenon has been observed in a number of cases (cf. Tables 3 and 4). In other words, reasoning from the data thus far available, there appears to be a degree of divergence which results in a maximum reaction. If this degree of divergence be either exceeded or decreased the reaction appears to diminish in intensity. One is immediately struck by the analogy to the "zone phenomenon" in animal immunology, where there is an optimum concentration for reaction, and where if this optimum be passed in either direction the reaction diminishes. There is one significant difference in the plant phenomenon, however, namely that whereas in the zone phenomenon one has to do solely with a quantitative optimum, in the case at hand it appears to be a qualitative difference which determines the optimum of reaction. Thus in the normal plant precipitin reactions the optimum condition for reaction, according to the hypothesis above, implies a qualitative difference in the reacting substances which must be neither too great nor too small. Hence, one would infer that a negative reaction might imply a very close relationship or a very great divergence, whereas a positive reaction would involve a definite degree of affinity. It would thus be impossible from a single reaction to judge the degree of affinity of two plants; such judgement could only follow from a consideration of the reactions of the plant in question in relation to the reactions of a number of related species. As a case in point, the first reactions performed with *Prunus* involved eight species. From the reactions thus obtained it was very difficult to arrive at a logical interpretation. Seven additional species of *Prunus* were chosen and tested against the original species and against one another. The result was that the seven additional species offered connecting links and transitions of such value that the fifteen species at once fell into a logical order, in fact an order which with but one exception agrees with the order of arrangement accepted by present-day taxonomists of the genus.

One other fact must also be taken into consideration. As is well known to taxonomists, groups of plants vary among one another in *variability*. A given character which may be very uniform in one heterogeneous group may be very variable in another more homo-

TABLE 3. NORMAL PRECIPITIN REACTIONS IN THE PRUNOIDEAE

Explanation in the text.

	Prunus spinosa	Prunus insititia	Prunus domestica	Prunus cerasifera	P. salicina × Simonii	Prunus maritima	Prunus hortulana	Prunus Armeniaca	Prunus Persica	Prunus Davidiana	Prunus pumila	Prunus serrulata	Prunus avium	Prunus serotina	Prunus Padus	Osmaronia cerasiformis	Prinsepia sinensis	Maddenia hypoleuca
Prunus spinosa	–	–	–	–	1	1	1	2	–	2	t	2	2	2	2	2	2	2
Prunus insititia	–	–	–	–	1	1	1	1	2	2				2	2			
Prunus domestica	–	–	–	–	–	–	2	1	t	2				2	2			
Prunus cerasifera	–	–	–	–	2	2	1	–	–	2				2	2			
Prunus salicina × Simonii	1	1	–	2	–	–	2											
Prunus maritima	1	1	–	2	–	–	1	2	2	2				2	2			
Prunus hortulana	1	1	2	1	2	1	–	2	t	–	–	–	–	–	–	–	–	–
Prunus Armeniaca	2	1	1	–		2	2	–	–	2	2	2	2	2	3	2	2	2
Prunus Persica	–	2	t	–		2	t	–	–	2				1	2			
Prunus Davidiana	2	2	2	2		2	–	2	2	–	t	1	2	–	–	–	–	–
Prunus pumila	t						–	2		t	–	–	–	–		t	–	–
Prunus serrulata	2						–	2		1	–	–	–	1		1	t	–
Prunus avium	2						–	2		2	–	–	–	1		2	2	–
Prunus serotina	2	2	2	2		2	–	2	1	–	–	1	1	–	–	1	–	–
Prunus Padus	2	2	2	2		2	–	3	2	–				–	–			
Osmaronia cerasiformis	2						–	2		–	t	1	2	1		–	–	–
Prinsepia sinensis	2						–	2		–	–	t	2	–		–	–	–
Maddenia hypoleuca	2						–	2		–	–	–	–	–		–	–	–

geneous group. Such is the case with the precipitin reaction. Because one finds the Caprifoliaceae to be rather uniformly negative among themselves whereas the genus *Prunus* exhibits a high degree of variability does not necessarily imply that the Caprifoliaceae as a group are more homogeneous than the genus *Prunus*. *Prunus* may be homogeneous in many characters, but in its precipitin reaction it exhibits a remarkable variability. Whatever the character chosen as fundamental in a taxonomic study, the same phenomenon occurs. Each group must be judged by itself and its phylogenetic relationships must at present necessarily be determined by no one character but by the bulk of evidence yielded by all characters, morphological, anatomical, cytological, genetic, and physiological.

TABLE 4. NORMAL PRECIPITIN REACTIONS IN THE SAXIFRAGACEAE

Explanation in the text.

	Philadelphus grandiflorus	Fendlera Wrightii	Jamesia americana	Deutzia scabra plena	Hydrangea paniculata	Schizophragma hydrangeoides	Itea virginiana	Ribes petraeum	Prunus Armeniaca	Robinia fertilis	Photinia villosa	Platanus acerifolia
Philadelphus grandiflorus	–	–	–	–	–	–	t	2	2	1	–	t
Fendlera Wrightii	–	–	3	1	–	–	2	3	3	2	2	1
Jamesia americana	–	3	–	–	–	t	–	2	3	t	1	–
Deutzia scabra plena	–	1	–	–	–	t	–	1	t	2	–	–
Hydrangea paniculata	–	–	–	–	–	1	t	2	2	2	–	–
Schizophragma hydrangeoides	–	–	t	t	1	–	1	2	3	2	–	t
Itea virginiana	t	2	–	–	t	1	–	2	2	1	1	t
Ribes petraeum	2	3	2	1	2	2	2	–	–	2	3	2
Prunus Armeniaca	2	3	3	t	2	3	2	–	–	3	2	3
Robinia fertilis	1	2	t	2	2	2	1	2	3	–	–	–
Photinia villosa	–	2	1	–	–	–	1	3	2	–	–	–
Platanus acerifolia	t	1	–	–	–	t	t	2	3	–	–	–

A COMPARISON BETWEEN THE SYSTEMATIC RELATIONSHIPS INDICATED BY THE EXPERIMENTS AND THE RELATIONSHIPS INDICATED BY MORPHOLOGICAL TAXONOMY

In projecting the normal precipitin reaction in plants as an aid in systematic studies of the plant groups it is of utmost importance to ascertain the degree of correlation which exists between the relationships as indicated by the reaction and those accepted by modern taxonomists. As has been pointed out an exact parallel with morphological systems is neither found nor to be expected.

TABLE 5. NORMAL PRECIPITIN REACTIONS IN THE CAPRIFOLIACEAE

Explanation in the text.

	Sambucus canadensis	Viburnum cassinoides	Symphoricarpus mollis	Dipelta ventricosa	Abelia Zanderi	Linnaea borealis	Kolkwitzia amabilis	Diervilla florida	Lonicera Myrtillus	Pyracantha coccinea	Deutzia scabra plena	Platanus acerifolia
Sambucus canadensis	–	–	–	–	–	–	–	–	–	–	–	–
Viburnum cassinoides	–	–	–	1	1	–	–	–	–	–	–	–
Symphoricarpus mollis	–	–	–	t	–	–	–	–	–	–	–	–
Dipelta ventricosa	–	1	t	–	–	–	1	–	–	–	t	–
Abelia Zanderi	–	1	–	–	–	–	–	–	–	1	t	–
Linnaea borealis	–	–	–	–	–	–	–	–	–	–	–	–
Kolkwitzia amabilis	–	–	–	1	–	–	–	–	–	–	–	–
Diervilla florida	–	–	–	–	–	–	–	–	–	–	–	–
Lonicera Myrtillus	–	–	–	–	–	–	–	–	–	–	–	–
Pyracantha coccinea	–	–	–	–	1	–	–	–	–	–	–	–
Deutzia scabra plena	–	–	–	t	t	–	–	–	–	–	–	–
Platanus acerifolia	–	–	–	–	–	–	–	–	–	–	–	–

However, the value of the reaction as a systematic tool depends upon a general conformity with our present knowledge of the main trends in taxonomy, and the present section will hence be devoted to a consideration of the question of whether such general conformity does exist. The discussion of the results of the precipitin experiments in relation to the systematic position of the plants tested must necessarily be confined to the broader, more pronounced re-

TABLE 6. KOSTOFF'S RECORD OF NORMAL PRECIPITIN REACTIONS IN THE SOLANACEAE, WITH THE GENERA ARRANGED ACCORDING TO THE SYSTEMATIC TREATMENT OF ENGLER-GILG—Explanation in the text.

	Lycium barbarum	Solanum nigrum	Solanum Dulcamara	Solanum Melongena	Solanum Lycopersicum	Solanum tuberosum	Capsicum pyramidale	Physalis peruviana	Datura Wrightii	Datura ferox	Nicotiana suaveolens	Nicotiana Langsdorfii	Nicotiana Tabacum	N. rustica × Tabacum	Nicotiana rustica	Nicotiana alata	Nicotiana paniculata	Nicotiana glauca	Nicotiana Rusbyi	Petunia violacea	Salpiglossis sinuata
Lycium barbarum	–	–	3	t	–	–	2	–	2	2	t	–	t	–	–	–	–	t	–	2	–
Solanum nigrum	–	–	–	–	–	–?	4	2	4		t	–	–	–	2	–	–	1	3	–	3
Solanum Dulcamara	3	–	–	–			4	4	4						–			–			4
Solanum Melongena	t	–	–	–	–		2	–	4		–	–	–	–	–	–	–	–	1	–	3
Solanum Lycopersicum	–	–		–	–	–	1		4	1	–		–	–	–	–	–	–	1	–	3
Solanum tuberosum	–	?			–	–	–	–	4			2	–	–	t	2	–	–	–		
Capsicum pyramidale	2	4	4	2	1	–	–	–	t		–	2	1	–	1	1	1	t	t	–	–
Physalis peruviana	–	2	4	–		–	–	–							3			2			–
Datura Wrightii	2	4	4	4	4	4	t		–				?								–
Datura ferox	2				1					–			2?			t					
Nicotiana suaveolens	t	t		–	–		–				–	–	1	–	–	–	–	–	3	–	–
Nicotiana Langsdorfii	–	–		–		2	2				–	–	–	–	–	–	–	–	3	1	–
Nicotiana Tabacum	t	–		–	–	–	1		2?	?	1	–	–	–	–	–	t	–	2	–	4
Nicotiana rustica × Tabacum	–	–		–	–	–	–				–	–	–	–	–	–	–	–	1	–	–
Nicotiana rustica	–	2	–	–	–	t	1	3			–	–	–	–	–	–	–	–	1	–	4
Nicotiana alata	–	–		–	–	2	1			t	–	–	–	–	–	–	–	–	1	–	–
Nicotiana paniculata	–	–		–	–	–	1				–	–	t	–	–	–	–	–	t	–	t
Nicotiana glauca	t	1	–	–	–	–	t	2			–	–	–	–	–	–	–	–	–	–	3
Nicotiana Rusbyi	–	3		1	1	–	t				3	3	2	1	1	1	t	–	–	3	–
Petunia violacea	2	–		–	–		–				–	1	–	–	–	–	–	–	3	–	–
Salpiglossis sinuata	–	3	4	3	3		–	–	–		–	–	4	–	4	–	t	3	–	–	–

lationships of the groups, since a detailed analysis of the value of each reaction would be possible only to a monographer of the respective groups equipped with a very extensive knowledge of the evidences of relationship yielded by several methods of approach.

Referring to Table 2 one is first impressed by the relative homogeneity of the Pomoideae. This point is in conformity with the findings of taxonomists in general that the Pomoideae as a whole represent a well marked and uniform subfamily. The one strong reaction indicated, that of *Mespilus* plus *Crataegus*, is susceptible to a somewhat different explanation than any of the other reactions indicated in this paper. *Mespilus* and *Crataegus* are assumed to be very closely allied. One would expect, if this be true, a negative reaction. The plant of *Mespilus* chosen, however, had been propagated by grafting upon *Crataegus*, and the reaction may very well represent a modification of the normal immunity. Passing outside the subfamily, the Spiraeoideae as represented by *Spiraea virginiana* show a close affinity to the Pomoideae, the Rosoideae would be somewhat farther removed, while the Prunoideae appear to be farthest removed of all from the Pomoideae. Such an arrangement as indicated by the precipitin reaction conforms to the opinion of Rehder and others that the Spiraeoideae are relatively close to the Pomoideae on the basis of morphology, while the Rosoideae and the Pomoideae are more divergent in the order named. It may be claimed that such a comparison as the above, based upon a single species of each subfamily, is unwarranted. It is indeed possible that a selection of numerous species of each subfamily would show variation among themselves in their reactivity toward the Pomoideae, but in the absence of more extensive data upon this point one may merely note that the species chosen at random do show such a progressive removal from the Pomoideae as would be expected from a knowledge of the taxonomy of the group involved. The other three genera chosen for testing against the Pomoideae are all hypothetically too far removed from that subfamily to show marked reactions.

Passing to the Prunoideae (Table 3) one is first impressed by the remarkable variability evidenced as compared with the Pomoideae. The Prunoideae as a whole are a much more complex group than the Pomoideae and such greater variability might well be anticipated. *Prunus spinosa* and *P. insititia* exhibit reactions very similar in general, conforming with their close morphological relationship. Moreover the Euprunus group (represented here by *P. spinosa*, *P. insititia*, *P. domestica*, *P. cerasifera*, and *P. salicina* × *P. Simonii*) as a whole are practically negative among one another but positive

to the remainder of the genus. The transition from the Euprunus group to *P. maritima* in *P. salicina* × *P. Simonii* is readily interpreted in the light of the close relationship of *P. maritima* to the Plums. The reactions of *P. Armeniaca*, *P. Persica*, and *P. Davidiana* in general are somewhat less uniform, although a relationship between *P. Armeniaca* and *P. Persica* is apparent. *P. Davidiana* diverges curiously, a point which might well be of interest to a student of the group. The Cherries as a group, *P. pumila*, *P. serrulata*, and *P. avium*, are well set off from the preceding members of the genus and are mutually negative as would be anticipated. Finally the Padus group, *P. serotina* and *P. Padus*, are mutually negative and show their only affinities with the Cherries, which is in accordance with taxonomic findings.

Certain exceptional reactions in the genus are of interest. Among these should be mentioned the aberrance of *P. hortulana* and the distinction among the Peaches already indicated. That *P. Persica* should react positively with *P. Davidiana* is certainly worthy of note. Finally as one passes outside the genus the reactions diminish in accordance with the hypothesis previously pointed out.

In the Saxifragaceae (Table 4) occur a number of interesting reactions. As a whole the group of reactions exhibits a parallel with the taxonomic treatments. *Ribes* is by far the most aberrant genus, as would be expected, with *Itea* following closely after. The strong reaction of *Fendlera* and *Jamesia* is worthy of comment, as the two genera are considered to be rather closely allied, while one is somewhat surprised at the slight divergence of *Hydrangea* and *Schizophragma*.

The Caprifoliaceae (Table 5) as a whole are rather disappointing from the standpoint of the precipitin reaction. The group is rather heterogeneous and a number of strong reactions were anticipated. However, as has been already suggested, the groups selected would be expected to vary from one another in variability and the technique would necessarily be of more value in some groups than in others. *Sambucus* is taxonomically very distinct from the rest of the family. Hypothetically its negative reactions may well indicate too great a divergence to result in positive tests. *Viburnum* of all the genera considered is most reactive, which accords with its intermediate position between *Sambucus* and the rest of the family. The *Dipelta-Kolkwitzia* reaction is puzzling, but *Dipelta* is rather aberrant and its aberrance as expressed by the precipitin reaction may well be greater than that which would be expected from a study of morphological structure.

Finally a consideration of the Solanaceae (Table 6) is of interest.

It should be recognized at the start that the reactions of the Solanaceae as here indicated were performed by a different worker, under different experimental conditions, and hence may not be strictly comparable to the results in the other tables. Attention is first directed to the reactions of the genus *Nicotiana*. As a whole the genus is very uniform, *N. Rusbyi* alone being divergent. The negative reactions of the latter with the other twelve-chromosome members of the genus, *N. glauca* and *N. paniculata*, may well be of significance, but its strong reactions with the remainder of the genus are problematical. The species of *Solanum* are uniformly negative with one another and thereby stand apart as a homogeneous group fairly closely allied, according to the reactions, with *Nicotiana*, *Capsicum* and *Physalis*, generally accepted as very close taxonomically, are mutually negative, and on the whole rather strongly set off from the neighboring genera. *Salpiglossis* and *Petunia* exhibit a like relationship, being mutually negative but distinct from all the other genera. Of all the groups considered the Solanaceae is probably the most complex and poorly defined. It is likely that many of the species are the products of a reticular phylogeny, and if this be true, the reactions are of particular interest. It may very well be that the group is so large that some of the more peripheral negative reactions represent divergence rather than affinity, but the positive reactions on the whole show a reasonable correlation with what is known of the relationships of the family.

It is of value at this point to consider the theoretical results of a series of precipitin tests in a circumscribed group in order to form a clearer conception of the correlation between the theoretical expectation and the experimental yield. Assuming a group of five species capable of being arranged in a linear series, each of the assumed species being equidistant in all characters from the two adjacent species, the reactions obtained would theoretically be of the general form:

	A	B	C	D	E
A	–	t	1	2	3
B	t	–	t	1	2
C	1	t	–	t	1
D	2	1	t	–	t
E	3	2	1	t	–

The significant facts to draw from such a theoretical table are that in the reactions of such an ideal group there would be a concentra-

tion of the strongest reactions in the upper right-hand and lower left-hand corners, that there would be a path of negative reactions extending along the opposite diagonal, and that the reactions would progressively increase in strength as one passed from any point on the diagonal toward the opposite corners of the table. The situation pictured, however, would rarely if ever obtain, since circumscribed groups of species or genera customarily tend to fall into a number of subgroups, each subgroup being relatively homogeneous and distinct as a body from the other subgroups. Selecting the genus *Prunus*, since that is the group which has been most thoroughly investigated from the standpoint of the precipitin reaction, one may plot a theoretical expectation for a group of species conforming in main outlines to this genus. Rehder's treatment of the genus (6) would divide the species considered in the following manner. The first eight species indicated in the table would fall into a single subgenus Prunophora. This group of eight may be further subdivided into three subgroups, a first subgroup (Euprunus) including *P. spinosa* to *P. salicina* × *P. Simonii*, a second subgroup represented by *P. maritima* and *P. hortulana* (Prunocerasus), and a third subgroup (Armeniaca) containing *P. Armeniaca*. *P. Persica* and *P. Davidiana* would represent the second subgenus (Amygdalus), *P. pumila*, *P. serrulata*, and *P. avium* the third (Cerasus), and *P. serotina* and *P. Padus* the fourth (Padus). In other words the species considered may be divided into six groups, consisting of 5, 2, 1, 2, 3, and 2 species respectively. If the theoretical yield of a body of fifteen species so divided be plotted, the resulting chart would have the general form of Table 7.

By comparing this theoretical arrangement of reactions with the actual reactions obtained in *Prunus* (Table 3) one immediately sees the resemblance. In the upper left-hand corner of each there is a block of negative signs indicative of the close relationship of the Euprunus group. The hybrid "Wickson" Plum (*P. salicina* × *P. Simonii*) alone begins to diverge from the Euprunus type. The path of negative reactions from upper left to lower right is well marked on both tables as is also the concentration of the more powerful reactions in the opposite corners. It will be observed that in the table of Prunus reactions the arrangement of Rehder was strictly followed. Several factors tend to cause some degree of divergence from the ideal grouping. Thus the ideal table assumes that the subgroups are perfectly homogeneous, that they are all equidistant from their adjacent subgroups, and that they can be arranged in a linear series. In actual practice none of these conditions obtains. The real relationships between the fifteen selected species

of *Prunus* could probably be represented only by a three-dimensional figure in part dendritic in form and in part reticular. Convergence undoubtedly accounts for some of the similarities. In practice these several factors lead to a certain amount of variation from the ideal distribution, but that the experimental chart in its general features conform strikingly to the ideal chart affords definite evidence of the value of the method in taxonomy and of the specificity of the reaction in immunology.

TABLE 7. THEORETICAL EXPECTATION OF PRECIPITIN REACTIONS IN AN IDEAL GROUP OF THE GENERAL STRUCTURE OF THE GROUP OF PRUNUS SPECIES TESTED (TABLE 3)

Explanation in the text.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
A	–	–	–	–	–	t	t	1	2	2	2	2	2	2	2
B	–	–	–	–	–	t	t	1	2	2	2	2	2	2	2
C	–	–	–	–	–	t	t	1	2	2	2	2	2	2	2
D	–	–	–	–	–	t	t	1	2	2	2	2	2	2	2
E	–	–	–	–	–	t	t	1	2	2	2	2	2	2	2
F	t	t	t	t	t	–	–	t	1	1	2	2	2	2	2
G	t	t	t	t	t	–	–	t	1	1	2	2	2	2	2
H	1	1	1	1	1	t	t	–	t	t	1	1	1	2	2
I	2	2	2	2	2	1	1	t	–	–	t	t	t	1	1
J	2	2	2	2	2	1	1	t	–	–	t	t	t	1	1
K	2	2	2	2	2	2	2	1	t	t	–	–	–	t	t
L	2	2	2	2	2	2	2	1	t	t	–	–	–	t	t
M	2	2	2	2	2	2	2	1	t	t	–	–	–	t	t
N	2	2	2	2	2	2	2	2	1	1	t	t	t	–	–
O	2	2	2	2	2	2	2	2	1	1	t	t	t	–	–

Finally lest it be asserted that the distribution of reactions obtained might well have been fortuitous, one may compute the probability that seventy-five reactions distributed at random might as closely resemble the ideal distribution as do the experimental results in Table 3. It will be found that the probability of such a distribution by chance alone is exceedingly small.

From the comparison which has been made between the relationships indicated by the reaction and those indicated by recent taxonomic studies, one can now reach a conclusion as to the systematic value of the reaction. It has been seen that on the whole the reactions are expressive of the same broad phylogenetic trends as are indicated by the conventional taxonomic methods. Incompatibilities do exist, although for the main part they are minor as compared with the main features of agreement. That there are such incompatibilities is no more characteristic of the precipitin technique than of other techniques of phylogenetic investigation, and the precipitin reaction thus offers to the intensive monographer at the same time a technique for shedding light upon his more debatable relationships, and a challenge in interpretation.

EVIDENCE AS TO THE NATURE OF THE REACTION

The taxonomic value of the reaction having been pointed out, it is desirable at this point to consider the evidence yielded by the experiments in hand as to the nature of the reaction. The precipitin technique may be interpreted either as a purely physical phenomenon, as a reaction of some non-specific chemical compound of the extracts, or finally as a reaction of the specific proteins of the extracts. It is important to know which of these interpretations is applicable not only in determining the stress which is to be laid upon the reaction from the phylogenetic standpoint, but also in evaluating the work which has been done in applying the technique to a study of plant immunity. In this, as in most other biological problems, the solution depends upon the evidence yielded by two main lines of investigation, the descriptive and the analytical. The present paper treats of the precipitin reaction from the descriptive approach. Before a final conclusion is reached as to the nature of the reaction and its consequent value in taxonomy, immunology, and parasitology, the analytical method must be applied. The reaction must be subjected to an intensive study employing the techniques of biochemistry. Such a study is now in progress, and upon the results will depend the final interpretation of the precipitin reaction in plants. Meanwhile, however, it is instructive briefly to point out the facts which have been yielded by the descriptive mode of attack as having a bearing upon the solution of the problem as to the nature of the reaction.

With regard to the hypothesis that the reaction may be due to purely physical variables, the evidence at present indicates that such is not the case. Kostoff (4), in an extensive series of pH determinations in the solanaceous extracts with which he worked,

showed that the precipitin reaction bears no relation to the pH of the extracts employed. The temperature of the extracts has been so fully controlled that it could not conceivably function as a cause for the precipitation. That the concentration of the extracts alone does not account for the reaction is evidenced by the facts that minor dilutions do not appreciably affect the reaction and that the progressive dilution of one or both of the extracts merely progressively weakens the precipitation. Furthermore, it is immaterial which extract be pipetted above the other in testing. The relative position of the extracts may be reversed without affecting the potency of the reaction. It is difficult to conceive of any other purely physical variable which could be responsible for the reaction.

With a purely physical explanation of the reaction thus eliminated one is forced to conclude that the precipitation is due either to the action of some non-specific chemical component of the extracts, or to a relatively specific substance of enzymatic nature, or to the highly specific proteins. It would exceed the bounds of scientific caution at present to attempt to ascribe the precipitin reaction to one of these three groups of substances. The specificity of the reaction and its general agreement with the complexity of the taxonomic treatments inclines one to the belief that specific proteins are involved. On the other hand, some of the reactions, such as those of *Prunus*, *Ribes*, and *Robinia* in Table 4 lead one to the suspicion that possibly some non-specific compound is acting in a rather complex fashion to produce the precipitates. As has been indicated above the solution of the problem of the nature of the reaction ultimately depends upon a chemical analysis of the reaction and it is more prudent to suspend decision until the results of the biochemical investigation are available.

PRACTICAL APPLICATION OF THE PRECIPITIN REACTION

A word should be introduced at this point regarding the practical application of the precipitin technique in systematic studies of plant groups. It has been shown in the preceding pages that the reaction bears a definite relation to the systematic position of the plants studied, and that this relation is too well correlated with taxonomic positions to be accidental. That we have in the precipitin reaction an additional taxonomic tool is apparent. The technique is somewhat tedious in application and as a result its employment will necessarily be limited to such debatable phylogenetic problems as must be attacked from every available angle. If the reaction is truly protein in nature it is conceivable that the evidence obtained is more fundamental than that yielded by a study of secondary char-

acters. In its present state of development the precipitin technique is necessarily limited to small groups and will prove to be much more sensitive in some groups than in others. A more explicit statement of the value of the reaction in systematic studies awaits a final determination of the nature of the reaction from the biochemical standpoint.

The method of direct precipitin testing in plants is not comparable to the technique involving the sensitization of animals with plant extracts. If proteins are involved the direct technique as outlined in the present paper has a number of advantages over the older technique. Among these advantages are the greater simplicity of application, the freedom from errors produced by the variability in the experimental animals, and the absence of more fundamental errors due to the fact that an animal sensitized to a given species of plant will react positively to the extract from a widely separated species containing an homologous protein. For as Wells and Osborne have pointed out (7) the same protein may occur in widely separated species, accompanying the proteins upon which depend the specificity of the respective species. The direct precipitin method reveals only the *differences* in reactivity of the extracts, homologous reactive substances being neutralized in the process of extraction. On the other hand, in its present form the direct precipitin technique is certainly much less sensitive than the blood technique, although the results as indicated in Tables 2–6 demonstrate that an application is useful in limited plant groups.

In conclusion it may be said that the positive reactions yielded by plant extracts in the presence of foreign extracts is indicative of a phase of immunity against disease which has as yet received scant attention in plant pathology. It is well known that susceptibility and immunity in plants in many cases depend on more than mechanical obstructions to the invading organism, the presence of toxins, or the absence of conditions vital to the development of the parasite. An application of the principle of incompatibility as developed above may well afford an answer to some of the heretofore inexplicable problems of the parasitology of plants.

SUMMARY

1. The present paper describes a series of tests of the direct normal precipitin reactions in a number of families of woody plants for the purpose of determining the specificity of the reaction and its consequent relation to applications of the method in phylogeny and immunology.

2. A marked advance in technique, namely the ability to utilize

dried leaf tissues in the tests, is described, and its advantages over the use of fresh tissues are pointed out.

3. In general the results of the experiments performed indicate a clear-cut parallel betweeen the systematic relationships as indicated by the precipitin reaction and the main trends of relationship as indicated by the conventional methods of taxonomy. The divergences from such a parallel are no greater than are found in the comparison of the relationships indicated by any two systematic methods. Uniform groups of plants are in general characterized by homogeneity in reaction and absence of mutual reactivity, whereas the reactions steadily increase as one passes farther from the type originally selected, reaching a maximum at a given distance from the type, and then again disappearing as the divergence of the plants hypothetically becomes too great to be expressed in reaction.

4. An analysis is made of the nature of the reaction on the basis of the evidence yielded by the study of normal precipitins. The hypothesis that the reaction may be due to purely physical variables is shown to be untenable, and attention is hence directed to the influence of specific components of the extracts studied.

5. The parallel obtained between the results of the precipitin tests and the accepted systematic relationships indicates the value of an application of the precipitin technique to intensive studies of circumscribed plant groups both in confirming the results of systematic investigations employing other methods of attack and in shedding light upon the more debatable relationships between certain genera and species.

6. The specificity manifested by the normal precipitin reaction affords definite indication of the value of an application of the technique in a study of the nature of immunity to disease in plants.

ACKNOWLEDGEMENT

The suggestions and criticisms of a number of the members of the staff of the Arnold Arboretum have assisted in the study herein reported. Acknowledgement is particularly due to Dr. Karl Sax who originally proposed that the work be undertaken and who aided materially in the selection of plants for investigation, to Professor J. H. Faull, and Dr. Edgar Anderson for numerous helpful suggestions, and to Dr. Ivan M. Johnston for valuable assistance in appraising the experimental data from the systematic viewpoint.

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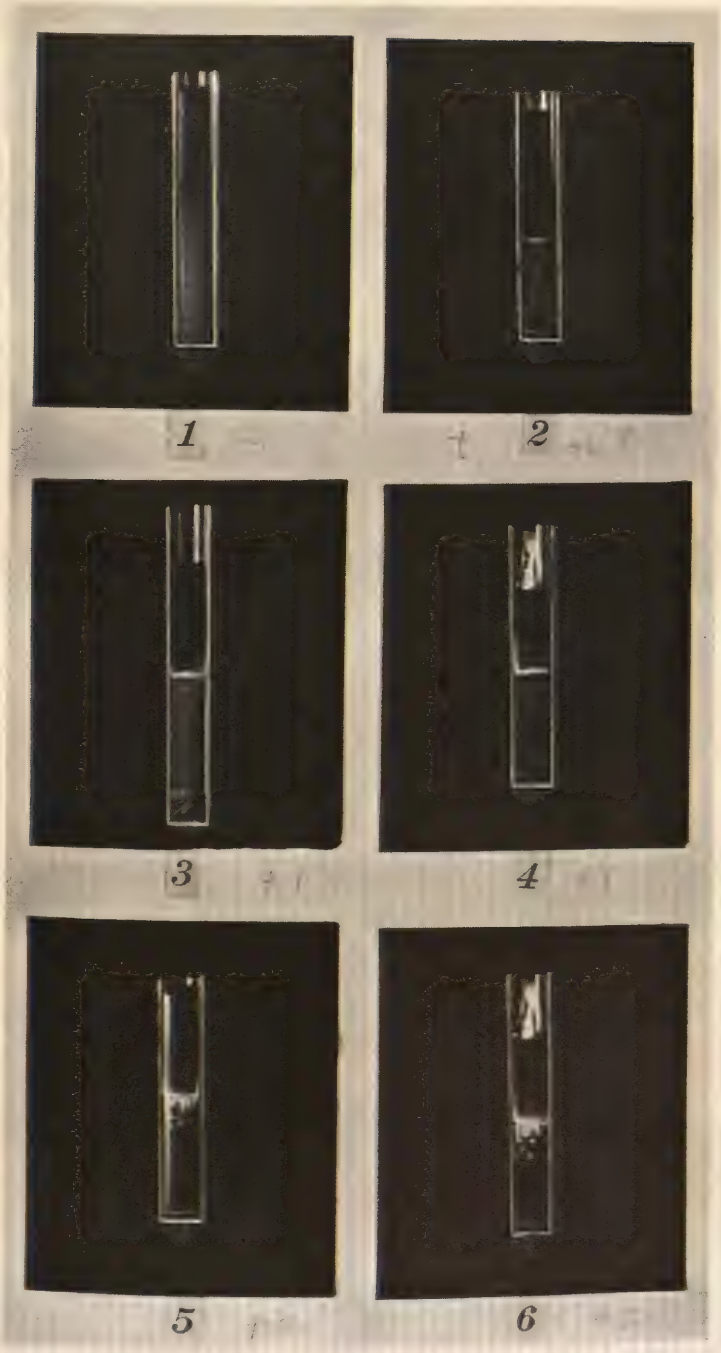
September 10, 1931.



Studies on the Precipitin Reaction in Plants

THE OCCURRENCE IN THE UNITED STATES OF CRYPTOCOCCUS FAGI (BAER) DOUGL., THE INSECT FACTOR IN A MENACING DISEASE OF BEECH

JOHN EHRLICH

THE BEECH SCALE, *Cryptococcus fagi*, has long been known in Europe as a common pest on *Fagus sylvatica* and its varieties. It has been found in practically every country of western Europe. Sporadically infestations have at times been followed by an extensive killing of Beech, but elsewhere no important damage has resulted. Studies on destructive epidemics have yielded some evidence that the immediate killing agents were certain fungi, species unable to secure a foothold on healthy uninjured bark, but capable of causing much damage if entrance has been made possible by the scale.

The first discovery of the scale in America was reported by Hewitt in 1914 on ornamental European Beeches and our native *Fagus grandifolia* in the vicinity of Halifax, Nova Scotia. Evidence was presented which indicated that it had been there since about 1890. Subsequent notes on its spread indicate that it is at present general throughout the Maritime Provinces of eastern Canada. But until now there has been no report of its having reached the United States.

In the earlier stages of the outbreak in Nova Scotia no serious damage to the Beech was noted, but eventually there set in a destruction of Beech on a wide scale and in alarming proportions. A pathological reconnaissance of the forests of Nova Scotia made in 1929 by Dr. J. H. Faull of the Arnold Arboretum, Harvard University, led him to conclude that the death of the Beech was immediately due to fungal action. A study of the problems involved was turned over to the writer in 1929, and is still in progress under the direction of Dr. Faull, supported by the National Research Council of Canada and the Arnold Arboretum.

RANGE IN THE UNITED STATES

Since the scale had not, apparently, been reported in the United States, an examination was begun of Beeches in the metropolitan district about Boston. In November, 1929, a light infestation of what appeared to be the Beech scale was found on the native Beeches in the Arnold Arboretum. In December, a more severe attack was discovered on some Beeches sheltered by Hemlocks in the Boston city park at Jamaica Pond. Some of this material was sent

to Dr. E. M. Patch and to Dr. Harold Morrison, both of whom independently stated that the insect was *Cryptococcus fagi*. The search was continued in the vicinity of Boston and infestations were located in several other places within the city, also in adjacent Brookline, and in Middlesex County. In the spring of 1931, the presence of the Beech scale in metropolitan Boston came to the attention of the United States Entomological Laboratory, Forest Insects Division, at Melrose Highlands, and the survey was continued by their staff, with the result that several additional outbreaks were located, ranging in Massachusetts from Gloucester on the north to the Blue Hills in Milton on the south, and westwards to Belmont and Newton. On November 5, 1931, a heavy infestation was found in Liberty, Maine, by members of the Melrose Highlands Laboratory. The age of the Boston attack cannot be stated with certainty; but its severity in isolated places and the comments of gardeners indicate that the insect has been present for approximately ten years.

Importance

It cannot be prognosticated how widespread or serious the scale is likely to become; but the general fatality of infested Beeches in Nova Scotia and New Brunswick resulting from fungal attack suggests a potential danger of the first importance. Slime fluxes are not infrequent on the infested trees in Massachusetts as they are in the Maritime Provinces, but these seem to be of only minor significance. The species of fungus responsible for the death of the Maritime beeches has not been found in Massachusetts although the writer has examined a large proportion of all the trees in the region known by him to be infested.

Life History of Cryptococcus fagi

The life history of *Cryptococcus fagi* was studied in Germany by Rhumbler (1915, 1922). He found that oviposition occurs from the middle of June to the end of October. The motile form I larvae hatch after a month, or longer in cooler weather. They are slender, 0.24–0.33 mm. in length, pale yellow in color, and equipped with active legs and five-membered antennae. These crawlers roam about the bark, generally in an upward direction, until a suitable resting place is found in a crevice of the bark, on the lower side of branches, or under the curly-threaded canopy of preceding generations. The stylets are inserted into the bark, the body increases in size to 0.35–0.38 mm., the legs lose their ability to move, exudation of white threads begins, and the insect is fixed in position for the remainder of its life. This change into the form II larva occurs in

the late autumn or the following February. Between April and July the form II larvae molt and become the nymphal form III, whose body length at first is 0.38–0.4 mm., whose legs are lacking, and whose antennae are two-membered. A second molt occurs soon after, followed by development into the egg-laying females, circular in outline and 0.5–0.8 mm. in size. Winged forms and males are lacking. The females oviposit periodically through the late summer and early autumn and die with the coming of the frosts. The life-cycle is thus annual.

The development of *C. fagi* in eastern America coincides with that in Europe. In Nova Scotia and New Brunswick, however, hatching does not begin until about the end of July and the crawlers stop roaming by the end of September. In Boston the period of larval activity is somewhat longer. Local dissemination of the insect is effected by wind-carriage of the crawlers and of bits of wool containing eggs, and within a beech stand by the travelling of the crawlers over the ground from one tree to another.

Control

The beech scale does not seem to be a serious pest unless accompanied by certain fungi. Although that danger is apparently not yet present in the eastern United States, the surest way to forestall the possibility is to eradicate the scale. Obviously when once an insect such as this one becomes widely established in the woodlands, as it has in the Maritime Provinces, eradication is a very serious problem. But in Massachusetts, with a range still limited in area and restricted largely to ornamental situations, control seems not only feasible but greatly to be desired.

With a view to selecting an easily obtainable and effective insecticide for New England use, preliminary tests were made in the late winter of 1931 with different strengths of commercial Sunoco Oil, home-made kerosene-soap emulsion, nicotine sulphate (Black Leaf 40), and lime-sulphur. The tests were made by soaking an infested area of bark with the aid of a hand spray gun and removing samples of the bark at once and at intervals of several days for microscopic examination. The efficacy of the various materials was determined by placing the bark on the stage of a binocular and gently raising individual nymphs from the bark with a needle so as not to injure them while thus forcibly withdrawing their stylets from the bark. They were then rolled over so that their ventral sides were uppermost. Those not killed by the insecticide indicated their vitality by waving the stylets above their bodies. Others, raised slightly, but not sufficiently to cause complete withdrawal of the stylets from

the bark, would wave their bodies about, pivoted only on the stylets. A sufficient number of nymphs was examined in this way from every bark sample so as to leave no doubt as to the effect of a particular treatment. The results of these preliminary tests are summarized in Table I.

TABLE I. PRELIMINARY TESTS WITH CONTACT INSECTICIDES FOR CONTROL OF THE BEECH SCALE

Material	Strength	Place	Effective	Partially Effective	Not Effective
Kerosene-soap emulsion	25%	Arnold Arboretum	*		
Kerosene-soap emulsion	25%	Jamaica Pond		*	
Sunoco Oil	1–25	Jamaica Pond		*	
Sunoco Oil	1–5	Middlesex Fells	*		
Black Leaf 40	1–50	Jamaica Pond			*
Black Leaf 40	1–50	Middlesex Fells		*	
Black Leaf 40	1–25	Middlesex Fells		*	
Black Leaf 40 plus Sunoco Oil	1–25 1–15	Middlesex Fells	*		
Lime-sulphur	app. 5° B.	Jamaica Pond			*

These results indicate that lime-sulphur and nicotine sulphate are not satisfactory materials but that Sunoco Oil and kerosene-soap emulsion are suitable.

Later in the spring of 1931 field tests were made with commercial equipment operated by regular park employees in the Arnold Arboretum, the Boston Parks, and the Middlesex Fells Reservation, using Sunoco Oil, kerosene-soap emulsion, and nicotine sulphate. The pertinent results of these tests are brought together in Table II.

It was concluded from these results that Sunoco Oil, 1–15, is the most satisfactory material. The critical factor in these tests seemed to be the ability of the operator to cover the entire surface of the tree with sufficient thoroughness so that the material wet the fluffy canopy protecting the insects and penetrated to their bodies. This was possible only with the oils. A few trees were also scrubbed with each of these materials, using a long pole with a scrub-brush screwed to one end. It was found that this method, when used with Sunoco Oil or kerosene-soap emulsion, was much the most thorough. But it is a difficult method and the labor and expense

involved make it applicable only in estates where a small number of valued shade trees are to be kept completely free of the scale.

Acknowledgments of assistance in the work done by the writer in Massachusetts are due to Professor J. H. Faull for direction; Mr. Richard Hayden, Superintendent of Parks for the City of Boston, for generous help in scouting and in making field control tests; Mr. C. W. Collins, in charge of the Melrose Highlands Laboratory, for scouting information and other assistance; Mr. L. V. Schmitt of the Arnold Arboretum and Mr. W. H. Mollins of the Middlesex Fells Reservation for aid in making control tests and for other courtesies extended.

TABLE II. FIELD TESTS WITH CONTACT INSECTICIDES FOR CONTROL OF THE BEECH SCALE

Material	Strength	Place	Number of Infested Trees Sprayed	Number of These Trees Scale-Free[1]	% Control
Sunoco Oil	1–15	Arnold Arboretum	15	15	100
Kerosene-soap emulsion	25%	Willow Pond Road, Boston	18	12	66⅔
Sunoco Oil, soap, and Black Leaf 40	1–10 ½ pint per 40 gallons	Middlesex Fells	69	69	100
water Black Leaf 40 soap	50 gallons ½ pint 2½ lbs	Jamaica Pond, Boston	9	0	0

[1] Number of these trees on which no living scale could be found on careful examination of accessible parts with a hand-lens a month after spraying.

SUMMARY

The beech scale of Europe, present and spreading in eastern Canada for many years, has recently been found to be abundant on Beeches in the vicinity of Boston, Massachusetts, and has just been discovered in one locality in Maine. Beeches in eastern Canada are dying in vast quantities through the attacks of fungi which grow in scale-infested bark; but these fungi have not been found on Beeches in Massachusetts. The insect has an annual life-cycle; dissemination is effected by eggs and larvae during the summer and autumn. Experiments with contact insecticides point to the efficacy of thoroughly spraying ornamental trees with Sunoco Oil or kerosene-soap emulsion.

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CONTRIBUTION TO THE FLORA OF THE NEW HEBRIDES

PLANTS COLLECTED BY S. F. KAJEWSKI IN 1928 AND 1929[1]

A. GUILLAUMIN

Plate 43 and two text figures

NYCTAGINACEAE

Calpidia excelsa Heimerl in Oesterr. Bot. Zeitschr. LXIII. 284 (1913).

Aneityum: Anelgauhat Bay, common in rain-forest up to 600 m., no. **974** (coll. *J. P. Wilson*), Aug. 1929 (large tree up to 0.60 m. diameter; flowers small, pink; fruit a small round berry).—Already found on Tanna; also Fiji, Society? and Bismarck Islands, New Guinea, Timor and Malaysia.—Vernacular name "Moca."

Cited erroneously from Norfolk Island, Australia and New Zealand by confusion with *C. Brunoniana* Heimerl.

AMARANTACEAE

Achyranthes aspera Linnaeus, Sp. Pl. 204 (1753).

Tanna: Lenakel, common in native gardens, rain-forest, at 150 m., no. **86**, March 3, 1928 (plant about 1 m. high, with pretty variegated leaves of pink and brown).—Also New Caledonia, Loyalty Islands, North Australia, Norfolk Island, Fiji, Tonga, Samoa, Cook, Society, Marquesas, Union, Ellice, Mariana and Bismarck Islands and Malaysia.

POLYGONACEAE

Polygonum minus Hudson, Fl. Angl. ed. 1, 148 (1762).

Eromanga: Dillon Bay, common in rain-forest at sea level, no. **339**, May 29, 1928 (a plant growing in semi-cleared patches of rain-forest; mixed with Nunpar-lell, Ney-wass and Ne-cit-ersif for medicine for sickness on left side of stomach).—Also New Caledonia, Australia (Queensland, New South Wales, Victoria, Tasmania), Malaysia (Java) and Philippines (Luzon).—Vernacular name "Neta-pea."

[1] Continued from Vol. XIII. 30.

Polygonum subsessile R. Brown, Prodr. Fl. Nov. Holl. 419 (1810).

Eromanga: Dillon Bay, common on banks of creeks and in swampy places at sea level, no. **367**, June 5, 1928 (large plant up to 1.25 m. high; flowers white).—Also New Caledonia and Australia (Queensland, New South Wales, Victoria, Tasmania).—Vernacular name "Ukut-ukut."

PIPERACEAE

Piper latifolium Forster f., Fl. Ins. Austr. Prodr. 5 (1786).

Aneityum: Anelgauhat Bay, common in rain-forest at sea level, no. **718**, Feb. 9, 1929 (plant up to 2.5 m. high; fruit brown when ripe; this is the wild Kava and is not used for drinking purposes). Tanna: Lenakel, common in heavy rain-forest soil at sea-level, no. **3**, Feb. 20, 1928 (broad leaved plant about 1.25 m. high; leaves bright green).—Banks Group: Vanua Lava, common in rain-forest at sea level, no. **436**, July 9, 1928 (plant up to 1.5 m. high; fruit red when ripe).—Already found on Tanna, Efate and Epi; also Society, Tonga and Fiji Islands and in Timor.—Vernacular name "Wild Kava" (under no. 718) and "Wild N'Kava" (under no. 436).

Piper methysticum Forster f., Pl. Esc. 76 (1786).

Tanna: Lenakel; common in rain-forest at 150 m., no. **119**, March 6, 1928 (plant 1.5 m. high; the roots make the native intoxicant N'Kava).—Already found on Efate; also New Guinea, Bismarck, Fiji, Society, Tonga, Marquesas and Wallis Islands and Hawaii.—Vernacular name "N'Kava."

Piper miniatum Blume in Verh. Batav. Genostsch. XI. 166 (1826).

Banks Group: Vanua Lava, common in rain-forest at 500 m., no. **463**, July 10, 1928 (parasite on rain-forest trees, fruit red when ripe).—Also New Guinea, Moluccas, Malaysia and Philippines.

Peperomia leptostachyoides C. De Candolle in Bull. Herb. Boiss. ser. 2, VIII. 330 (1908).

Eromanga: Dillon Bay, common on rocks in shade of scrub or rain-forest at sea level, no. **359**, June 4, 1928 (plant about 7 cm. high; sap of leaf used to make the faces of the natives glossy). Efate: Fila Island, Vila, common in rain-forest of sea shore, no. **188**, April 14, 1928 (small plant growing on rocks).—Already found in the New Hebrides.—Vernacular name "Nimtoro-orah" under no. 359).

CHLORANTHACEAE

Ascarina lanceolata Hooker f. in Jour. Linn. Soc. I. 127 (1856).

Tanna: Mt. Tokosh Meru, common in rain-forest at 1000 m., no. **152**, March 15, 1928 (tree up to 10 m. high). Aneityum:

Anelgauhat Bay, common in rain-forest at 360 m., no. **863**, March 5, 1929 (small tree up to 9 m. high; flowers yellow; bark brown and fissured).

The plant from Tanna differs from the typical form of the Fiji and Samoa Islands in the larger leaves (up to 10.5 cm. by 4.5 cm.) and the longer petioles (up to 2.5 cm.), while the plant from Aneityum has narrower lanceolate leaves (up to 12 cm. by 3 cm.).

MYRISTICACEAE

Myristica aff. *M. Hollrungii* Warburg.

Banks Group: Vanua Lava, common in rain-forest at sea level, no. **422**, July 6, 1928 (tree up to 25 m. high; fruit brown, 4.5 cm. long, 4 cm. diam.)

No *Myristica* had been found in the New Hebrides, though Warburg (Monog. Myrist. p. 486) indicates that *M. subulata* Miq. of the Aru Island and New Guinea might exist perhaps also in the New Hebrides.

MONIMIACEAE

Hedycaria neo-ebudica Guillaumin, sp. nov.

Arbor parva, 10 m. alta, ramis gracilibus glabris, foliis oppositis vel 3-nis atro-viridibus papyraceis oblongis vel oblongo-elongatis (usque ad 16 cm. × 5.5 cm.) apice acute acuminatis basi obtuse cuneatis vel sub-rotundatis integerrimis utrinque glabris, nervis 7–10-jugis a venis parum distinctis procul a margine arcuatis tenuissimis subtus tantum prominulis, petiolo 2–2.5 cm. longo; inflorescentiae 3–4.5 cm. longae, receptaculo fructifero plano supra puberulo, drupis maturite nigris ovoideis (0.8 cm. × 0.6 cm.).

Aneityum: Anelgauhat Bay, common in rain-forest at 125 m., no. **811** (typus), Feb. 23, 1929 (small tree up to 9 m. high; leaves dark green; fruit 8 mm. long, 6 mm. in diam., black when ripe). Eromanga: Dillon Bay, common in rain-forest at 400 m., no. **322**, May 28, 1928 (tree about 8 m. high; fruit 1.25 cm. long, turbinate with blunted point, very scarce).—Vernacular name "Neyyar-riverum" (under no. 322).

This new species approaches *H. denticulata* Perk. & Gilg of the Solomon and perhaps the Tonga Islands, but is readily distinguished by the receptacle being pubescent above. The specimen from Eromanga differs from the type in the oval leaves (not exceeding 10 × 4.5 cm.) with shorter acumen and broader base and in the shorter, 1–2 cm. long petiole.

Hedycarya, sp. nov.?

Tanna: Lenakel, common in rain-forest at 200 m., no. **90**, March 5, 1928 (specimens from tree about 6 m. high).

LAURACEAE

Cryptocarya Wilsonii Guillaumin, sp. nov.

Arbor parva, trunco 30 cm. diam., ramis glabris, foliis ovatis (usque ad 19 cm. × 10 cm.) breviter acuminatis basi subito cuneatis glabris, nervis lateralibus 5–8-jugis, petiolo 1–1.5 cm. longo. Paniculae usque ad 6 cm. longae axillares, ramulis pedicellisque breviter rufo-velutinis, floribus minimis (1 mm. longis) breviter pedicellatis (sub 1 mm.) vel sessilibus, bracteis minimis lanceolatis in utraque pagina rufo-velutinis, perianthio campanulato fere usque ad medium 6-lobato, segmentis ovatis carinatis extra dense intus sparsius rufo-velutinis, staminibus generis, subsessilibus, connectivis pilosis, antheris lanceolatis apice muticis, staminodiis omnino sessilibus staminibus similibus sed latioribus apiceque acutis, ovario glabro, stylo subulato staminum apicem subattingente; fructus transverse ellipsoidei (2 cm. × 2.6 cm. × 2 cm.), pericarpio tenui.

Aneityum: Anelgauhat Bay, scarce in rain-forest at 175–500 m., no. **951** (coll. *J. P. Wilson*) Sept. 1929 (low tree to 30 cm. in diam., leaves large; flowers small, yellow; fruit round 2.5 cm. in diam., seeds eaten by natives).—Vernacular name "Inceohp."

The fruit resembles particularly that of *C.*[1] *obcordicarpa* Lecard ex Guillaumin of New Caledonia.

Cryptocarya sp.

Aneityum: Anelgauhat Bay, scarce in rain-forest at 300 m., no. **950** (coll. *J. P. Wilson*) Sept. 1929 (small tree; leaves small, pointed, with yellow midrib; flowers white; fruit round, 1.8 cm. diam.)—Vernacular name "Ingeyho."

Beilschmiedia sp.

Aneityum: west coast, common in rain-forest up to 450 m., no. **964** (coll. *J. P. Wilson*) Sept. 1929 (tall tree up to 60 cm. in diam., leaves medium; flowers small, white; fruit red, 2 cm. long, 1.7 cm. in diam.)—Vernacular name "Nipicgow."

Endiandra aneityensis Guillaumin, sp. nov.

Arbor parva, 10 m. alta, trunco 22 cm. diam., ramis compressis cortice rubro, novellis rufo-puberulis cito glabris, foliis ovatis (8–12 cm. × 3–5 cm.) lutescente viridibus apice basique cuneatis pergamentaceis vel leviter coriaceis costae basi excepta glabris penninerviis, in utraque pagina dense reticulato-nervosis, petiolo 1 cm. longo puberulo. Paniculae axillares, circa 5 cm. longae, sparse puberulae, floribus coeruleis distincte (1–3 mm.) pedicellatis, peri-

[1] Owing to a typographical error *C. lifuensis* and *C. macrocarpa* (Bull. Soc. Bot. France, LXXI. 1103. 1925) have been attached to the genus *Cassytha*, but by referring to p. 1105 one finds these species in the key of *Cryptocarya*.

anthio sphaerico 2 mm. diam. extra sparsissime puberulo intus glabro, apice lobis 6 ovato-triangularibus 0.5 mm. longis reflexis glaberrimis, staminibus 3 perianthii ore erectis fere 1 mm. longis glabris, filamentis basi utrinque glandula parva globosa donatis, antheris ovatis, staminodiis 3 glandulis simillimis, ovario glabro ovato in stylum attenuato, stigmate 2-lobo. Fructus nigri, ellipsoidei (3.5 cm. × 2.5 cm.).

A n e i t y u m : Anelgauhat Bay, common in rain-forest at 25 m., no. **704** (typus), Feb. 4, 1929 (large tree up to 20 m. high, leaves light green); common in rain-forest at 175–500 m., no. **955** (coll. *J. P. Wilson*), Sept. 1929 (low tree up to 21.5 cm. diam., flowers small, blue; fruit 3 cm. long, 2.5 cm. in diam., edible, eaten by natives).—Vernacular name "Incitray" (under no. 955).

This species is very remarkable on account of the spherical rather than campanulate shape of the tube of the perigone.

Litsea aneityensis Guillaumin, sp. nov.

Arbor magna, 13 m. alta, trunco 25 cm. diam., innovationibus fulvo-tomentosis cito glabris, foliis ovatis (5.5–10 cm. × 3–6 cm.) leviter coriaceis apice acutis vel subacuminatis basi cuneatis penninerviis, nervis circa 6-jugis, venis subtus dense reticulatis, petiolo 1–1.5 cm. longo. Umbellulae fasciculatae, 1.2 cm. longae, axillares, albae, 4–5-florae, pedunculo 5–8 mm. longo, involucri phyllis 4–5 mm. longis ovatis margine parce ciliatis, pedicello usque ad 5 mm. longo, perigonii tubi lobis 0, staminodiis circa 6, antheris ad laminam lineari-lanceolatam reductis, omnibus filamentis 2-glandulosis dorso sparse ciliatis, ovario glabro. Fructus rubri, ovoidei (2 cm. × 1.5 cm.) in tubo staminodifero calycem simulante 7 mm. diam. insidentes.

A n e i t y u m : Anelgauhat Bay, common in rain-forest at 70 m., no. **748** (typus), Feb. 12, 1929 (large tree up to 12 m. high; stamens and anthers white); southwest, common in rain-forest at 60 to 275 m., no. **960** (coll. *J. P. Wilson*), Sept. 1929 (low tree up to 40 cm. diam.; flowers small, white; fruit red, 2 cm. long, 1.8 cm. in diam.)—Vernacular name "Incipet" (under no. 960).

This species resembles most *L. minor* Teschn. of New Guinea.

Litsea tannaensis Guillaumin, sp. nov.

Arbor circa 7 m. alta, innovationibus fulvo-tomentosis citissime glabris, foliis ovatis (4.5–7.5 cm. × 2.5–4 cm.) apice obtusis vel obtuse acuminatis basi late cuneatis leviter coriaceis penninerviis, nervis 5–6-jugis, venis immersis fere inconspicuis, petiolo 0.5–1 cm. longo. Umbellulae singulae vel fasciculatae, ad axillas foliorum vel foliorum delapsorum, 1 cm. longae, albae, 5-florae, pedunculo

5 mm. longo, involucri phyllis 4, 3 mm. longis ovatis margine parce ciliatis, pedicello brevi vel 0, perianthii tubi lobis 0, staminibus 6–9, 3–6 longioribus filamentis antheris 3-plo longioribus glandulis 2 globosis pedicellatis ad apicem munitis, 3–0 interioribus brevioribus filamentis antheris 2-plo longioribus, nonnunquam glandulis pedicellatis ad apicem destitutis, pistillo 0.

Tanna: Lenakel, common in rain-forest at 200 m., no. 109, March 6, 1928 (tree about 7 m. high; flowers white).

This species seems nearest to *L. maluensis* Teschn. of New Guinea from which it is chiefly distinguished by the perianth having no lobes.

HERNANDIACEAE

Hernandia cordigera Viellard in Ann. Sci. Nat. sér. 4, XVI. 69 (1861).

Aneityum: Anelgauhat Bay, common in rain-forest at 50 m., no. 703, Feb. 4, 1929 (large tree up to 20 m. high; petals white; used by the natives for canoe-making). Tanna: Lenakel, common in rain-forest at 150 m., no. 125, March 7, 1928 (tree 20 m. high, 70 cm. in diam.). Eromanga: Dillon Bay, centre of island, common in rain-forest at 400 m., no. 341, June 1, 1928 (large tree up to 20 m. high; petals dirty cream-colored; fruit 4.5–5.5 cm. long tapering to a blunt point; wood white, soft and used for canoe building).—Also in New Caledonia.

Hernandia peltata Meisner in De Candolle, Prodr. XV. pt. 1. 263 (1864).

Aneityum: Utgi, common along seashore at 90 m., no. 1001 (coll. *J. P. Wilson*), Sept. 1929 (large tree to 1 m. diam.; flowers yellow, clustered; fruit round, red, clustered). Eromanga: Dillon Bay, common in rain forest and along seashore, sea level, no. 307, May 25, 1928 (large straight tree up to 25 m. high, 75 cm. diam.; petals white, stamens yellow, stigma pale purple; this tree has a very soft wood and is used for canoe-building). Banks Group: Vanua Lava, common in rain-forest at sea level, no. 435, July 10, 1928 (large tree, wood used by natives for canoes).—Already found on Efate; also New Caledonia, Fiji, Tonga, Wallis, Cook, Society, Marquesas, Union, Ellice, Marshall, Mariana, Santa Cruz, Solomon, Bismarck and Admiralty Islands, New Guinea and Malaysia.—Vernacular names "Nogogu" (under no. 1001) and "Nehele" (under no. 307).

PROTEACEAE

Kermadecia lutea Guillaumin, sp. nov.

Arbor magna, 20 m. alta, ramis validis primum dense fulvo-pilosis deinde glabris, foliis ovato-lanceolatis (usque ad 14 cm. × 6 cm.)

primum dense fulvo-pilosis deinde glabris apice acute attenuatis basi cuneatis supra lutescentibus coriaceis, costa supra lutea, nervis 4-jugis subtus prominentibus, venis reticulatis subtus prominentibus, petiolo usque ad 4.5 cm. longo. Inflorescentiae axillares, foliis subaequilongae primum dense fulvo-pilosa, deinde glabrae, racemosae, floribus luteis in ramo circa 3 mm. longo 2-nis oblique sessilibus, bracteis 0, perigonii tubo recto basi oblique dilatato extra fulvo-piloso 1 cm. longo per anthesin uno latere fisso, segmentis concavis lanceolatis dein solutis, antheris ovatis sessilibus, disco unilaterali carnoso, ovario oblique sessili glabro ut stylo cylindrico, stigmate leviter incrassato. Fructus racemosi, in pedicello robusto 1 cm. longo singuli, curvatim ovati, leviter compressi (3–4 cm. × 2–3 cm. × 1.5–2 cm.), apice apiculati, nigri, exocarpio tenuissimo, endocarpio 2 mm. crasso osseo, semine 1 valde compresso.

Aneityum: Anelgauhat Bay, common in rain-forest 275 m., no. **901** March 11, 1929 (large tree up to 18 m. high; leaves with light yellow midribs; fruit 4 cm. long, 2.75 cm. in diam.; wood beautifully grained similar to the Queensland silky oak); no. **828**, Feb. 28, 1929 (tall tree up to 12 m. high; fruit 3 cm. long, 2.5 cm. in diam., yellow when ripe).—Tanna: Mt. Tokosh Meru, rain-forest, 400 m., no. **167** (typus) March 15, 1928 (flowers yellow; fruit black).—Vernacular name "Silky Oak" (under no. 167).

This species resembles, particularly in its leaves, *Adenostephanus austro-caledonicus* Brongn. & Gris of New Caledonia, which, as also Bentham and Hooker believe, must be a *Kermadecia*, but its flowers are unknown.

Grevillea elaeocarpifolia Guillaumin, sp. nov.

Arbor magna, 12 m. alta, ramis crassis cinereis primum rubiginose tomentosis deinde glabris, foliis lanceolatis (usque ad 14 cm. × 3.5 cm.) apice acutis mucronulatisque basi acutis, nervis 15–18-jugis tenuibus infra prominulis, venis reticulatis immersis, petiolo circa 1 cm. longo primum rubiginose tomentoso mox glabro. Inflorescentiae e ramis veteribus ortae, racemosae, usque ad 15 cm. longae, sparse tomentosae, floribus luteis pedicello 1 cm. longo suffultis, perigonii tubo basi oblique dilatato extra sparse puberulo 1.5 cm. longo per anthesin uno latere fisso, segmentis ovatis concavis tarde solutis, antheris sessilibus ovatis, disco unilaterali carnoso, ovario stipitato stipite 3 mm. longo, stylo 13–14 mm. longo apice incrassato, stigmate terminali conico. Fructus indehiscentes, maturitate lutei, curvatim ovoidei, lateraliter compressi (2.5 cm. × 2.3 cm. × 1.8 cm.), apice apiculati, pericarpio usque ad 5 mm. crasso lignoso, seminibus 2 plano-compressis orbicularibus margine alatis.

T a n n a : Lenakel, not common in rain-forest at 200 m., no. 95 (typus) March 5, 1928 (tree about 12 m. high; flowers yellow; fruit yellow when ripe; nuts eaten by natives). E r o m a n g a : Dillon Bay, not common in rain-forest at 400 m., no. 350, June 1, 1928 (tree up to 10 m. high; fruit yellow when ripe; nuts eaten by natives). —Vernacular names "Ngye-ngye" (under no. 95) and "Ugkom-ukom" (under no. 350).

The genus is essentially Australian and New Caledonian (with the exception of the Loyalty Islands), but has two representatives in New Guinea.

THYMELACEACEAE

Wikstroemia viridiflora Meisner in Denkschr. Bot. Ges. Regensb. III. 286 (1841).

T a n n a : Lenakel, common in rain-forest at 200 m., no. 107, March 6, 1928 (small shrub 2 m. high; flowers cream-colored). E r o m a n g a : Dillon Bay, common in poor red soil, bracken country at 300 m., no. 302, May 24, 1928 (small shrub 2–3 m. high; flowers cream-colored; bark thrown into pools to stupefy fish so they can be caught by hand).—Also New Caledonia, Loyalty, Fiji and Cook Islands and Australia (Queensland, New South Wales, North Australia).—Vernacular name "Tao-wap" (under no. 302).

LORANTHACEAE

Elytranthe banksiana Guillaumin, sp. nov.

Glaberrima, ramis gracilibus, foliis spathulatis (5–8 cm. × 2–2.5 cm.) apice rotundatis basin versus in petiolum indistinctum attenuatis crassis, nervis immersis. Inflorescentiae racemosae (?), pedicello 5 mm. longo, bractea late ovata 1 mm. longa, calycis parte libera tubum 1 mm. longum leviter patulum formante, petalis aureis apice rubris, tubo 4 cm. longo, supra medium sensim dilatato, longitudinaliter costato, lobis 5–6 linearibus reflexis 1.5 cm. longis, staminibus 5–6 erectis corollae lobis brevioribus, antheris filamentis leviter brevioribus linearibus, ovario omnino infero, stylo filiformi basi conice incrassato stamina superante, stigmata capitato.

B a n k s G r o u p : Vanua Lava, common in rain-forest at 300 m. no. 453, July 10, 1928 (parasitic plant growing on a tree where sunlight is available; very pretty golden petals with red ends).

Loranthus aneityensis Guillaumin, sp. nov.

Ramis gracilibus cinereis, foliis obovatis (3–4 cm. × 2–2.5 cm.) apice rotundatis basi plus minusve subito in petiolum indistinctum cuneatis valde coriaceis, venis inconspicuis. Inflorescentiae 3 cm. longae, umbellatim cymosae, ramis rubiginoso-puberulis, bracteis

triangulari acuta vel ovata extra dense rubiginos-opuberula, calycis parte libera tubum brevissimum campanulatum formante, petalis aurantiacis liberis 5 lineari-lanceolatis 2 cm. longis extra sparse puberulis, staminibus 5 erectis corollae lobis aequilongis, antheris filamentis aequilongis apice muticis, ovario omnino infero, obconico, dense rubiginoso-puberulo, stylo filiformi petalis aequilongo, basi disco annulari cincto, stigmate capitellato. Fructus ovoidei (5 mm. × 4 mm.), minimi, rubiginose puberuli.

Aneityum: Anelgauhat Bay, common in rain-forest at 300 m., no. 753, Feb. 12, 1929 (parasite growing upon trees in the open partly cleared scrub land; flowers orange-colored).

Loranthus ficivorus Guillaumin, sp. nov.

Ramis sat robustis dense rugose lenticellatis cinereo-fulvis, foliis late obovatis (5–7 cm. × 3.5–5 cm.) apice rotundatis basi in petiolum indistinctum cuneatis valde coriaceis, venis 2-jugis immersis. Inflorescentiae 4 cm. longae, umbellatim cymosae, ramis fulvo-puberulis, bractea ovata extra fulvo-puberula, calycis parte libera tubum brevissimum extra fulvo-puberulum formante, petalis basi roseis apice luteis liberis 5 linearibus ad 2.5 cm. longis, staminibus corollae lobis leviter brevioribus, antheris filamento 1.5-plo brevioribus, connectivo apice leviter globose producto, ovario omnino infero turbinato fulvo-puberulo, stylo filiformi petalis aequilongo, basi disco annulari cincto, stigmate capitellato.

Tanna: Lenakel, common in rain-forest at 60 m. no. 94, March 5, 1928 (parasitic on Ficus; flowers pink at base with yellow tips).

The specimen no. 87, March 3, 1928, from Tanna: Lenakel, common in rain-forest at 150 m. (commonly parasitic on rain-forest trees) with less thick leaves and ellipsoid fruit (1 cm. × 0.6 cm.) probably belongs to the same species.

SANTALACEAE

Santalum austro-caledonicum Vieillard in Ann. Sci. Nat. sér. 4, XVI. 61 (1861).

Aneityum: Anelgauhat Bay, common in rain-forests at 180 m., no. 814, Feb. 23, 1929 (small tree up to 9 m. high; flowers cream-colored; fruit purple when ripe; this is exported as the sandalwood of commerce). Eromanga: Dillon Bay, common in rain-forest at 300 m., no. 287, May 23, 1928 (tree up to 20 m. high; leaves light green above, silvery underneath; flowers cream-colored; fruit 1.5 cm. long, 1 cm. in diam., black when ripe; the sandalwood of commerce).—Already recorded from Aneityum and Eromanga; also New Caledonia and Loyalty Islands.—Vernacular name "Worlu" (under no. 287).

EUPHORBIACEAE

Euphorbia obliqua Endlicher, Prodr. Fl. Norf. 85 (1833).

E r o m a n g a : Dillon Bay, common on rocky beach at sea level, no. **257**, May 15, 1928 (small plant about 25 cm. high, growing in the crevices of rocks; flowers white; sap used in conjunction with charcoal for tatooing, producing blue marks).—Already found on Aneityum and on Eromanga; also New Caledonia, Loyalty, Norfolk and Tonga Islands.—Vernacular name "Uripatepu."

Phyllanthus, sp. nov. ?

A n e i t y u m : Anelgauhat Bay, common in rain-forest up to 150 m., no. **912**, March 11, 1929 (small tree up to 6 m. high; flowers brown).

Phyllanthus sp.

A n e i t y u m : Anelgauhat Bay, common in rain-forest at sea level, no. **908**, March 11, 1929 (small tree up to 6 m. high; fruit 0.5 cm. long, light pink when ripe). T a n n a : Lenakel, common in rain-forest at 100 m., no. **73**, March 1, 1928 (small tree about 8 m. high). E r o m a n g a : Dillon Bay, common in rain-forest at 300 m., no. **274**, May 17, 1928 (small tree up to 10 m. high; fruit red; leaves crushed and used by natives for fevers).

This seems to belong to the same group as *P. Gaudichaudii* Muell. Arg. of the Samoa and Tonga Islands, New Guinea, Aru Island and the Mariana Islands.—Vernacular name "Narmlee" (under no. 274).

Glochidion tannaense Guillaumin, sp. nov.

Arbor, ramulis leviter compressis glabris, foliis lanceolatis (usque ad 7 cm. × 3 cm.) apice basique acutis rigide membranaceis infra pallidioribus, nervis circa 7-jugis tenuissimis, petiolo 4–5 mm. longo, stipulis lineari-lanceolatis cito caducis petiolo 2-plo brevioribus, floribus ♀ circa 6, pedicellis circa 5 mm. longis gracilibus apicem versus leviter incrassatis, tepalis 6 vix 1 mm. longis ovatis obtusis, ovario glabro 10-loculari, columna stylari conica superne angustata et ovario continua.

T a n n a : Lenakel, common in rain-forest at 200 m., no. **91**, March 5, 1928 (tree of large dimensions with numerous roots of the banyan type; flowers yellow).

Though the staminate flowers are not known, there can be no doubt, that it is a *Glochidion* which should be placed near *G. lucidum* Bl. of Malaysia and *G. novo-guineense* K. Schum. of New Guinea. Could this be the *Glochidion* sp. found on Tanna by Forster?

Hemicyclea Deplanchei (Brongn. & Gris) Baillon apud Guillaumin in Ann. Mus. Col. Marseille, sér. 2, IX. 224 (1911).

Aneityum: Anelgauhat Bay, common in rain-forest at 150 m., no. **933**, March 17, 1929 (large tree up to 18 m. high; fruit 1.4 cm. long, 1 cm. in diam., yellow when ripe).—Also New Caledonia.

Bischofia javanica Blume, Bijdr. 1168 (1826).

Eromanga: Dillon Bay, common in rain-forest at sea level, no. **310**, May 26, 1928 (large tree up to 25 m. high; bark is boiled in salt water and applied to cuts).—Also New Caledonia, Australia (Queensland), Fiji, Tonga, Cook and Society Islands and Malaysia.—Vernacular name "No-ghor."

Aleurites moluccana Willdenow, Sp. Pl. IV. 590 (1805).

Eromanga: Dillon Bay, common in rain-forest at sea level, no. **242**, May 14, 1928 (very fine tree with a straight barrel up to 20 m. high; kernel of fruit threaded on a cocoanut fibre used as a candle).—Already found on Efate; also New Caledonia, Loyalty Islands, Australia (Queensland), New Zealand, Fiji, Tonga, Samoa, Cook, Society, Marquesas, Gambier and Mariana Islands, New Guinea, Malaysia and Hawaii.—Vernacular name "Candle-nut."

Croton insularis Baillon in Adansonia, II. 217 (1861–62).

Aneityum: Aname, locally common in lower ranges up to 150 m., no. **988** (coll. *J. P. Wilson*), Sept. 1929 (small tree to 23 cm. in diam.; leaves broad; flowers small, brown; fruit small 0.6 cm. in diam.). Eromanga: Dillon Bay, common in rain-forest at sea-level, no. **267**, May 17, 1928 (small tree up to 15 m. high; leaves green above, silvery brown underneath).—Also New Caledonia, Loyalty Islands, Australia (Queensland, New South Wales).—Vernacular names "Nalipes" (under no. 267), "Imrath" (under no. 988).

Codiaeum variegatum (L.) Bl. var. **moluccanum** (Decne.) Mueller Arg. in DeCandolle, Prodr. XV. pt. II. 1119 (1866).

Banks Group: Vanua Lava, common in rain-forest at sea level, no. **409**, June 5, 1928 (small tree up to 12 m., high; flowers white); no. **423**, July 6, 1928 (small tree up to 7 m. high; leaves dark green).

Codiaeum variegatum (L.) Bl. var. **pictum** (Lodd.) Mueller Arg. in DeCandolle, Prodr. XV. pt. II. 1119 (1866).

Tanna: Lenakel, common in rain-forest at 100 m. no. **31**, Feb. 21, 1928 (shrub up to 6 m. high, with pretty variegated leaves).

This species has been found already on Aneityum, Tanna, Efate, and Mallicolo; also New Caledonia, Loyalty Islands, Australia (Queensland), Fiji, Tonga, Samoa, Cook, Marshall, Caroline, Mariana, Santa Cruz, Solomon, Bismarck and Admiralty Islands, New Guinea and Malaysia.

Alphandia furfuracea Baillon in Adansonia, XI. 86 (1873).

A n e i t y u m : Anelgauhat Bay, common in rain-forest at 90 m. no. **809**, Feb. 23, 1929 (large tree up to 12 m. high; leaves dark green, midrib yellow; flowers creamy yellow; fruit 2.5 cm. long, 2 cm. in diam., light yellow).—Also New Caledonia.

Fontainea Pancheri (Baill.) Heckel, Thèse Inaug. Montpell. 1870, apud Baillon in Adansonia XI. 80 (1873).

A n e i t y u m : Anelgauhat Bay, common in rain-forest at sea level, no. **906**, March 11, 1929 (small tree up to 9 m. high; fruit 5 cm. long, 4 cm. in diam., orange-colored when ripe; this tree contains a remarkable poison throughout and is used for poisoning fish.)—Also New Caledonia and Loyalty Island.

Claoxylon insulanum Mueller Arg. in Linnaea XXXIV. 164 (1865–66).

A n e i t y u m : south west, common in rain-forest at 60–300 m. no. **958A** (coll. *J. P. Wilson*), Sept. 1929 (small tree, trunk 22.5 cm. in diam.; flowers small, white; fruit a small berry). E f a t e : Undine Bay, common in rain-forest at 500 m., no. **232**, April 28, 1928 (tree 10–15 m. high).—Also New Caledonia and Loyalty Islands.—Vernacular name "Namchrai" (under no. 958A).

Claoxylon taitense Muell. Arg. var. **neo-ebudicum** Guillaumin, var. nov.

A planta taitensi differt racemis brevioribus (2.5–6 cm. longis), floribus 3–5-fasciculatis, glabris, petioli glandulis subulatis glandulis minimis adjunctis.

E r o m a n g a : Dillon Bay, common in rain-forest at 400 m., no. **347**, June 1, 1928 (tree about 15 m. high; flowers white).—Vernacular name "Ney-emptey."

The type of the species occurs in Tahiti and New Caledonia.

Acalypha grandis Bentham in Lond. Jour. Bot. II. 232 (1843).

T a n n a : Lenakel, common in heavy rain-forest soil at sea level, no. **16**, Feb. 21, 1928 (small tree growing in semi-cleared land).—Already found on Aneityum; also New Caledonia, Loyalty, Fiji, Wallis, Tonga, Samoa, Bismarck and Admiralty Islands, New Guinea, Moluccas and Malaysia.

Acalypha neo-caledonica Mueller Arg. in DeCandolle, Prodr. XV. pt. II. 812 (1866).

T a n n a : Lenakel, common in rain-forest soil at sea level, no. **21**, Feb. 21, 1928 (small shrub up to 4 m. high). E r o m a n g a : Dillon Bay, common in rain forest at 300 m., no. **383**, June 8, 1928 shrub up to 5 m. high).—Already found on Aneityum; also New

Caledonia and Loyalty Islands.—Vernacular name "Nau-nompe pura-puri" (under no. 383).

Acalypa sp., an *A. Forsteriana* Muell. Arg.?

Eromanga : Dillon Bay, common in rain-forest at sea level, no. 248, May 15, 1928 (small tree up to 5 m. high).—Vernacular name "Nau-numpey."

Identical with no. 1 of Levat from Efate, vernacular name "Nocfis."

Acalypha Forsteriana, endemic in the New Hebrides, has been already found on Tanna and Efate.

Cleidion angustifolium Pax & K. Hoffmann in Engler, Pflanzenr. IV.-147. pt. VII. 293 (Euphorbiac.) (1914).

Aneityum : south west, common in lower hills up to 60 m. no. 959 (coll. *J. P. Wilson*), Sept. 1929 (small tree up to 25 cm. diam.; flowers very small, white; fruit a small berry).—Also New Caledonia.—Vernacular name "Nijivit."

The character "ovarium sparsissime adpresse pilosum" brings the species not near *C. spathulatum* Baill. but near *C. Vieillardii* Baill. var. *acutifolium* Muell. Arg.

Cleidion Vieillardii Baill. var. **acutifolium** Mueller Arg. in De Candolle, Prodr. XV. pt. II. 986 (1866).

Aneityum : Anelgauhat Bay, common in rain-forest at 240 m., no. 909, March 11, 1929 (small tree up to 9 m. high, flowers minute, white).—Also New Caledonia.

Macaranga Tanarius (L.) Mueller Arg. in DeCandolle, Prodr. XV. pt. II. 997 (1866).

Tanna : Lenakel, common in heavy rain-forest soil at sea level, no. 17, Feb. 21, 1928 (tree up to 15 m. high).—Already found on Tanna; also New Caledonia, Australia (Queensland, North Australia, New South Wales), Bismarck Islands, New Guinea, Moluccas and Malaysia.

The plant from Tanna corresponds to var. *genuina* Muell. Arg., while the plant of New Caledonia is pubescent, but as indicated by J. J. Smith and later by Pax and Hoffmann, all intermediate stages are found.

It is very probable that *Ricinus Mappa* Forst. also collected on Tanna (Forster, no. 213) belongs to this species.

Macaranga sp.

Tanna : Lenakel, common in rain-forest soil at 100 m., no. 37, Feb. 21, 1928 (tree 12–15 m. high, about 20–40 cm. diam.). Eromanga : Dillon Bay, common in rain-forest at 300 m., no. 319,

May 28, 1928 (tree about 10 m. high; dried leaf bandaged over sore to heal it).—Vernacular name "Norvo-among" (under no. 319).

Macaranga sp.

Aneityum: Anelgauhat Bay, common in rain-forest at sea level, no. 708, Feb. 10, 1929 (small tree up to 10 m. high; leaves dark green above, silvery underneath; stamens and anthers cream-colored). Banks Group: Vanua Lava, common in rain-forest at sea level, no. 440, July 9, 1928 (small tree up to 7 m. high).

These four specimens all staminate possibly belong to the same species.

Homalanthus ebracteatus Guillaumin, sp. nov.

Arbor 8 m. alta, trunco 15 cm. diam. omnino glabra, ramis tortuosis, foliis rhomboideo-ovatis (2–3.5 cm. × 2–4 cm.) apice rotundatis vel brevissime acutis basi obtuse truncatis, petiolo 1–3 cm. longo apice 2-glanduloso. Racemi erecti, circa 4 cm. longi, floribus singulis ♂ ebracteatis, ♀ bractea naviculari apice cuspidata basi cordata breviter pedicellata involucratis, floribus ♂ patentibus, pedicello 2 cm. longo supra medium vel ad apicem glandulis 2 hemisphaericis notato, sepalo parvo reniformi, antheris circa 20, floribus ♀ ad racemi basin 1–2 nutantibus, pedicello 3 mm. longo, tepalis 3 semi-circularibus bene distinctis, stylo brevi, stigmatibus 3-plo longioribus apice 2-lobis. Fructus ovoideo-compressi, carpellorum dorso carinatis.

Tanna: Lenakel, common in rich rain-forest soil at 200 m. no. 47, Feb. 24, 1928 (tree about 8 m. high, about 15 cm. diam.).

The pedicels of the staminate flowers without bracts at the base but furnished with two glands below the middle represent an entirely new type in the genus which is worthy to constitute a new series EBRACTEATI.

Homalanthus longipes Pax & K. Hoffmann in Engler, Pflanzenr. IV.-147. pt. v. 51 (Euphorbiac.) (1912). Eromanga: Dillon Bay, common in rain-forest at sea level, no. 263, May 17, 1928 (tree up to 15 m. high; leaves silvery underneath).—Already found on Eromanga.—Vernacular name "Nemtar-bwar."

The specimen lacks pistillate flowers.

Homalanthus nutans (Forst.) Pax var.

Aneityum: Anelgauhat Bay, common in rain-forest at 600 m., no. 976 (coll. *J. P. Wilson*), Aug. 1929 (tree to 0.30 m. diam.; flowers very small, yellow; fruit flattened 1 cm. long, 0.7 cm. in diam.).—Already found on Tanna, Eromanga and Efate; also New Caledonia, Loyalty, Fiji, Tonga, Samoa, and Society Islands.—Vernacular name "Ettaing."

Excoecaria Agallocha Linnaeus, Syst. Nat. ed. 10, 1288 (1759).

Aneityum: Anelgauhat Bay, common along seashore, no. 694, Feb. 4, 1929 (tree up to 15 m. high; sap milky). Tanna: Lenakel, common in heavy sandy soil of seashore, no. 1, Feb. 20, 1928 (spreading tree about 12 m. high, with numerous spreading stems or coppice growth; fruit dark brown when ripe; sap milky).—Already found on Efate; also New Caledonia, Loyalty Islands, Australia (Queensland, North Australia), Norfolk Island, Fiji, Tonga, Caroline, Mariana, Solomon and Bismarck Islands, New Guinea and Malaysia.

BALANOPSIDACEAE

Trilocularia pedicellata Guillaumin, sp. nov.

Arbor parva, ultra 6 m. alta, ramis erectis teretibus glabris, foliis alternis ad ramulorum apicem congestis ovatis (4–7 cm. × 2–4 cm.) valde obtusis basi rotundatis leviter coriaceis, marginibus recurvatis, nervis vix conspicuis concoloribus, petiolo 0.5–1 cm. longo. Fructus 1 cm. pedicellati, bracteis 4 minimis sparsis, bracteis involucrantibus 8, interioribus sensim majoribus et 5 mm. longis, orbicularibus margine ciliatis, glandi simillimi, circa 1.5 cm. × 1 cm., stylorum 3 usque ad basin 2-fidorum reliquiis coronati, loculis 3.

Banks Group: Vanua Lava, common in rain-forest on tops of high mountains at 600 m., no. 476, July 12, 1928 (small tree up to 6 m. high).

This species on account of its pedicelled fruit is very distinct from *T. sparsiflora* Schlechter of New Caledonia, the only species of the genus hitherto known.

The family thus was represented outside of New Caledonia only by a single species found only once in Queensland.

CELTIDACEAE

Celtis paniculata Planchon in Ann. Sci. Nat. sér. 3, x. 305 (1848).

Aneityum: Anelgauhat Bay, common in rain-forest at sea level, no. 927, March 19, 1929 (large tree up to 15 m. high; fruit black when ripe).—Also New Caledonia, Loyalty Islands, Australia (Queensland, New South Wales, North Australia), Norfolk Island and Society Islands.

Trema Vieillardii Schlechter in Engler, Bot. Jahrb. xxxix. 96 (1906).

Aneityum: Anelgauhat Bay, common in rain-forest at sea level, no. 717, Feb. 9, 1929 (small tree up to 15 m. high; fruit brown-black when ripe). Eromanga: Dillon Bay, common in rain-forest at sea level, no. 398, June 8, 1928 (tree up to 10 m. high;

used for rafters of native houses).—Also New Caledonia and Loyalty Islands.—Vernacular name "Nendog" (under no. 398).

MORACEAE

Pseudomorus Brunoniana Bureau in Ann. Sci. Nat. sér. 5, XI. 371 (1869).

Aneityum: Anelgauhat Bay, common on seashore, no. 926, March 17, 1929 (small tree up to 9 m. high).—Also New Caledonia, Australia (Queensland, New South Wales), Norfolk Island, New Guinea and Hawaii.

ARTOCARPACEAE

Ficus L.

Determined by V. S. SUMMERHAYES

Sect. PALAEOMORPHE

Ficus Decaisneana Miquel, Fl. Ind. Bat. I. pt. II. 312 (1859).
Ficus philippinensis var. *sessilis* Bureau in Ann. Sci. Nat. sér. 5, XIV. 253 (1872).

Banks Group: Vanua Lava; sea level, rain-forest, common, no. 493, July 18, 1928 (large tree 20 m. high). Eromanga: Dillon Bay, sea level, rain-forest, common, no. 265, May 17, 1928 (Fig with straight barrel instead of the usual contorted type; fruit yellow to purple when ripe); alt. 300 m., rain-forest, common, no. 395, June 8, 1928 (small tree 10 m. high).—Vernacular names "Nevelisi" (under no. 395) and "Nervelisen" (under no. 265).

Careful comparison of these specimens with some of those cited by Bureau from New Caledonia and with others from New Guinea and eastern Malaya has convinced me that they all belong to the same species. Although Bureau compares his new variety with *F. subulata* Bl., his description does not mention any hermaphrodite flowers, only male and female ones, and does not specify whether the latter are perfect or galled. The New Caledonian specimens at Kew examined by me bear female receptacles only, but both types occur on the New Hebridean specimens and in the galled receptacles good hermaphrodite flowers were found. In King's monograph the perianth of *F. Decaisneana* is shown as glabrous but this does not seem to be so in any of the specimens I have seen, the lobes being always slightly pubescent or ciliolate and sometimes thickly so. They are, however, always quite free, which sharply distinguishes the species from *F. subulata*, the vegetative characters of which are very similar.

The length of the receptacular stalk is not a constant feature

in *F. Decaisneana* and cannot in my opinion be used for separating a variety from the type. There are specimens at Kew with almost sessile receptacles from almost the whole range of the species although they are commonest in New Caledonia and the New Hebrides.

Ficus neo-ebudarum Summerhayes, sp. nov.

Arbor parva usque 10 m. alta vel frutex scandens; ramuli cortice brunneo primo sparse scabridulo leviter sulcato demum fere laevi obtecti. Folia alterna, breviter petiolata, oblique et inaequaliter ovata, apice breviter acuminata, basi late cuneata vel saepius rotundata, 7–14 cm. longa, 3.5–7 cm. lata, coriacea, omnino glabra, laevia, costa supra vix prominula subtus prominente, nervis lateralibus utrinsecus 6–8 e costa angulo 55–70° exeuntibus prope marginem arcuatim conjunctis supra vix prominulis subtus prominentibus, rete venularum distincto saepe siccitate distinctissimo sed vix prominulo; petiolus crassiusculus, 6–15 mm. longus, mox cortice in laminas parvas tenuissimas decorticante obtectus; stipulae lanceolatae, acuminatae, glabrae. Receptacula axillaria, solitaria vel gemina, alia flores ♂ et ♀ cecidiophoros alia flores ♀ includentia, pedunculata, subsphaeroidea, rubra, 10–12 mm. diametro, sparse scabridula, umbicilo prominulo, ostioli bracteis subprominentibus; pedunculus falsus (stipes receptaculi) gracilis, 4–6 mm. longus, basi bracteis tribus ovatis acutis 1 mm. longis instructus, pedunculo vero interdum brevi. Flores ♂ prope ostiolum, sessiles vel saepissime pedicellati, perianthii segmentis 4 linearibus vel anguste lanceolatis acutis, ovarium et antheram superantibus basi sparse pubescentibus; stamen 1, anthera 1 mm. longa; ovarium cecidiophorum ellipsoideum, stylo infra-apicali brevi; pedicellus pubescens. Flores ♀ cecidiophori sessiles vel usque 3 mm. longe pedicellati, perianthii segmentis 3–4 eis florum ♂ similibus; ovarium ellipsoideum, 1.5 mm. longum, laeve, stylo infra-apicali, stigmate parvo clavato. Flores ♀ sessiles vel usque 1.5 mm. longe pedicellati, perianthio gamophyllo demum irregulariter fisso quam ovario longiore inferne pubescente; ovarium reniformi-ellipsoideum, 2 mm. longum, rugulosum, stylo infra-apicali vel laterali, stigmate clavato.

Tanna: Lenakel, alt. 150 m., rain-forest, common, no. 79, March 3,1928 (small tree 10 m. high). Aneityum: west coast, Aname, alt. 150 m., lower ranges and sea-shore, common, no. 995 (coll. *J. P. Wilson*) (type), Sept. 1929 (large vine on forest trees; flowers red, small; fruit red, 12 mm. diameter).—Vernacular name "Nedeug" (under no. 995).

A very close relative of *F. tinctoria* Forst. from which it differs

in the smaller, definitely acuminate leaves and the larger flowers, of which the perianth is only sparsely pubescent at the base. There are specimens of *F. tinctoria* at Kew from Tahiti, Tonga, Samoa and Fiji and these are remarkably constant in the features mentioned above.

Sect. UROSTIGMA

Ficus acrorrhyncha Summerhayes, sp. nov.

Arbor magna, trunco 2–3 m. diametro. Ramuli teretes, glabri, demum cortice pallide brunneo leviter ruguloso obtecti, lenticellis ± rotundatis pallidis instructi. Folia petiolata, elliptica, oblongo-elliptica vel ovato-elliptica, apice subito anguste et retrorsum acuminata, basi obtusa, latissime cuneata vel subrotundata, 5–10 cm. longa, 3–6 cm. lata, utrinque glabra, supra praesertim juniora subnitida, costa supra impressa subtus prominente, nervis lateralibus utrinsecus 7–10 rectis vel levissime curvatis basalibus angulo 50–60° ceteris angulo 60° e costa exeuntibus supra prominulis subtus prominentibus nervo submarginali leviter curvato conjunctis, nervis secondariis parallelis crebris, rete venularum subtus distinctissimo; petiolus gracilis, 1–2.5 cm. longus, supra canaliculatus, glaber; stipulae lanceolatae, acuminatae, extra adpresse sericeo-pubescentes. Receptacula axillaria, solitaria, sessilia, ellipsoidea vel subglobosa, circiter 15 mm. longa, 10–12 mm. diametro, siccitate rugosa, glabra, lenticellis rotundatis, ostioli bracteis paulo prominentibus, basi bracteis tribus late reniformibus arcte adpressis instructa. Flores ♂, ♀ et ♀ cecidiophori commixti. Flores ♂ longe pedicellati, perianthii segmentis 4 liberis obovatis vel obovato-orbicularibus 1 mm. longis glabris stamen singulum arcte includentibus. Flores ♀ cecidiophori pedicellati, perianthii segmentis eis florum ♂ similibus, ovario sessili ellipsoideo 1.5 mm. longo, stylo 0.5 mm. longo, stigmate breviter clavato. Flores ♀ breviter pedicellati vel saepius sessiles, perianthii segmentis 3–4 ovatis vel lanceolatis 0.7 mm. longis glabris, ovario ovoideo 1.3 mm. longo, stylo 2 mm. longo, stigmate cylindraceo-clavato 0.7 mm. longo.

Aneityum: Umage, alt. up to 460 m., rain-forest, common, no. 999 (coll. *J. P. Wilson*), Sept. 1929, (large tree up to 3–4 m. diam.; flowers small, yellow; fruit 15 mm. diam.).—Vernacular name "Nepluth."

This typical member of sect. Urostigma is allied to *F. dictyophlebia* F. Muell., *F. retusa* L. and *F. benjamina* L., from all of which it is easily distinguished by the very abrupt and narrow acumen to the leaves. *F. retusa* has shorter and stouter petioles while the fruit possesses a distinct calyculus. In *F. benjamina*

and *F. dictyophlebia* the leaves are more gradually acute with the veins much more prominent on the upper surface and the petioles are shorter, while the fruits are smaller in *F. benjamina*. Those of *F. dictyophlebia* are unknown.

Ficus austro-caledonica Bureau in Ann. Sci. Nat. sér. 5, XIV. 267 (1872).

Aneityum: Anelgauhat Bay, alt. 240 m., rain-forest, common, no. **862**, March 5, 1929 (small tree 6 m. high; fruit 18 mm. long, 22 mm. diam., purple when ripe); s. w. coast, alt. up to 600 m., rain-forest, common, no. **975** (coll. *J. P. Wilson*), Aug. 1929 (small tree 45 cm. diam.; flowers red; fruit 18 mm. diam., red).—Vernacular name "Natinaia" (under no. 975).

This species strongly resembles *F. granatum* Forst. in leaf characters. It may, however, be distinguished by the slightly different venation of the leaves, the smaller receptacles with an easily detachable skin, the inside of the receptacles and the stalks of the flowers being almost or quite glabrous, and by the perianth of the female and gall flowers splitting irregularly into usually broad portions. In *F. granatum* the female perianth consists of five free, linear, acute segments which usually considerably overtop the ovary or achene.

Ficus glandifera Summerhayes, sp. nov.

Arbor magna, habitu *F. indicae* L. similis. Ramuli crassi, juniores sparsiuscule pubescentes, demum glabrescentes, cortice brunneo obtecti, cicatricibus foliorum et stipularum delapsorum valde notati. Folia petiolata, late ovata, apice breviter acuminata, acuta, basi obtusissima vel saepius rotundata, 7–14 cm. longa, 4–8 cm. lata, costa supra impressa subtus prominente, nervis lateralibus utrinsecus 20–30 parallelis e costa angulo 70–80° exeuntibus utrinque distinctis supra prominulis nervo submarginali curvato conjunctis, nervis secondariis numerosis subparallelis crebris, rete venularum subtus distincto, coriacea, supra subnitentia, utrinque glabra; petiolus pro rata gracilis, supra leviter canaliculatus, 3–4.5 cm. longus, glaber; stipulae non visae, ut videtur caducae. Receptacula axillaria, singula vel gemina, sessilia vel subsessilia, oblongo-ellipsoidea, circiter 4.5 cm. longa, 2.5 cm. diametro, apice in mammillam 5 mm. diametro producta, ostiolo ipso leviter depresso bracteis haud manifestis, bracteis basalibus in cupulam circiter 1 cm. longam breviter pubescentem receptaculo adnatam connatis, receptacula ergo glandes Querci specierum simulantia; pedunculus usque 4 mm. longus, saepius brevissimus, 4 mm. diametro. Flores ♂, ♀ et ♀ cecidiophori commixti.

Flores ♂ longipedicellati, perianthii segmentis 4 liberis ellipticis vel ovatis valde concavis vix 1 mm. longis glabris stamen singulum arcte includentibus, pedicello bracteis duabus lanceolatis instructo. Flores ♀ cecidiophori pedicellati vel rarius sessiles, perianthii segmentis eis florum ♂ similibus, ovario sessili, stylo brevi, stigmate clavato. Flores ♀ sessiles, ovario ovoideo 1.5 mm. longo, stylo infra-apicali 2.5 mm. longo, stigmate minuto.

Tanna: Lenakel, alt. 200 m., rain-forest, common, no. 80, March 3, 1928 (large tree of grand proportions with many roots, "4 m. in diam."; fruit orange-colored). Aneityum: Anelgauhat Bay, sea level, rain-forest, common, no. 802, (type), Feb. 21, 1929 (large tree of spreading banyan type, very beautiful; fruit orange-color when ripe, 4.5 cm. long, 2.5 cm. in diam.).

The species, with its remarkable acorn-like fruit, is allied to a group of four species occurring in Queensland, viz: *F. cylindrica* Warb., *F. Baileyana* Domin, *F. crassipes* F. M. Bailey and *F. Watkinsiana* F. M. Bailey. The two last-named differ in having the tip of the fruit drawn out into a point, as well as in the shape of the leaves and other features. *F. cylindrica* is the most closely related to *F. glandifera*, but differs in the possession of larger, relatively narrower oblong leaves with different venation and longer petioles, in the receptacles being definitely stalked and the cupule at the base being relatively smaller. *F. Baileyana* has leaves very similar to those of our species but the receptacles are much smaller, and have a poorly developed bracteal disc at the base and a slender stalk.

Ficus granatum Forster, Pl. Esc. 37 (1786).

Eromanga: Dillon Bay, alt. 400 m., rain-forest, common, no. 324, May 29, 1928 (large tree 25 m. high; leaves bright green; inside bark used to make cloth as it is glutinous). Tanna: Lenakel, alt. 100 m., rain-forest, common, no. 124, March 7, 1928 (tree 20 m. high; fruit 3–4 at end of each branch, pink when ripe, 4 cm. long, 3 cm. diam.). Aneityum: Anelgauhat Bay, alt. 30 m., rain-forest, common, no. 732, Feb. 11, 1929 (large tree 18 m. high; fruit red when ripe); alt. 15 to 450 m., common, no. 956 (coll. *J. P. Wilson*), Sept. 1929 (low tree 60 cm. diam.; leaves heavily veined; flowers small, red; fruit brown, edible).—Vernacular names "Nating" (under no. 956) and "Nah-tong" (under no. 324).

A striking species of sect. Urostigma which is closely allied to *F. callosa* Willd. and *F. austro-caledonica* Bureau. The differences between it and the latter are mentioned under that species. From *F. callosa*, *F. granatum* is distinguished by its gradually pointed

leaves with the main lateral nerves joining near the margin more simply, the receptacles being red or purple when ripe, and being thickly hairy inside, this also applying to the pedicels of the flowers. In general floral and vegetative characters the species are otherwise very similar.

Ficus obliqua Forster, Prodr. Fl. Ins. Austral. 77 (1786).

Eromanga: Dillon Bay, sea level, rain-forest, no. 253, May 15, 1928 (common throughout group growing into large tree of many branches and roots; fruit orange-color). Tanna: Lenakel, alt. 200 m., rain-forest soil, common, no. 67, Feb. 24, 1928 (large tree 15–20 m. high, 60 cm. to 1 m. in diameter; fruit brown when ripe). Aneityum: Anelgauhat Bay, sea shore, rain-forest, common, no. 781, Feb. 19, 1929 (large tree with spreading head; fruit orange-color when ripe).—Vernacular name "Nar-evirepp" (under no. 253).

Ficus prolixa Forster, Prodr. Fl. Ins. Austral. 77 (1786).

Ficus prolixoides Warburg in Fedde, Rep. Nov. Spec. I. 79 (1905).—**Synon. nov.**

Eromanga: Dillon Bay, alt. 300 m., rain-forest, common, no. 273, May 17, 1928 (giant Banyan of many trunks and roots; fruit black when ripe). Tanna: Lenakel, alt. 100 m., rain-forest, common, no. 29, Feb. 21, 1928 (large tree of many trunks sending down many roots, up to 25 m. high; fine shade tree); alt. 200 m., rain-forest, common, no. 113, March 6, 1928 (largest Banyan on Tanna). Aneityum: Anelgauhat Bay, sea level, rain-forest, common, no. 900, March 15, 1929 (large spreading Banyan, 18 m. high; fruit 10 mm. long, 8 mm. in diam., black when ripe).—Vernacular name "Nepang" (under no. 273) and "Banyan" (under nos. 29 and 900).

I cannot distinguish *F. prolixoides* Warb. from this species; the material at my disposal shows that the differences given by Warburg are not constant.

Sect. SYCIDIUM

Ficus aspera Forster, Pl. Esc. 36 (1786).

Tanna: Lenakel, alt. 200 m., rain-forest, common, no. 49, Feb. 24, 1928 (small tree 8 m. high; fruit red when ripe); alt. 200 m., rain-forest, common, no. 103, March 5, 1928 (tree 8–12 m. high; fruit yellow, eaten by natives).

Ficus ciliata Warburg in Bot. Jahrb. XXV. 615 (1898).

Aneityum: Anelgauhat Bay, sea level to 100 m. alt., rain-forest, common, no. 731, Feb. 11, 1929 (large tree 18 m. high;

fruit red when ripe, 14 mm. diam., flattened at the ends); sea level, sea shore, common, no. 788, Feb. 20, 1929 (small tree 6 m. high; fruit red when ripe, 15 mm. diam., flattened at top).

This species, which has been previously recorded only from Samoa, differs from *F. Kajewskii* Summerhayes in the larger receptacles and ciliate perianth lobes.

Ficus copiosa Steudel, Nomencl. ed. 2, 635 (1840).

Banks Group: Vanua Lava, sea level, rain-forest, common, no. 469, July 12, 1928 (small Fig 10 m. high, with fruit growing on trunk). Tanna: Lenakel, alt. 100 m., rich rain-forest soil, common, no. 24, Feb. 21, 1928 (tree 10–12 m. high; fruit red when ripe and growing on side of wood).

This species is also represented at Kew by New Hebridean specimens collected by Miss Cheesman and by Dr. A. Morrison. It is easily recognized by the fact that cork is formed at an early stage at both ends of the petioles but not in the middle. The specimens, in addition to agreeing with the description and the plate in King's monograph (the latter a reproduction of Roxburgh's original drawing), match the specimens collected in Amboina by C. B. Robinson and distributed by Merrill as *Ficus wassa* Roxb. In the writer's opinion these latter specimens are better referred to *F. copiosa* Steud. (*F. polycarpa* Roxb., non Jacq.). It is interesting to note from Roxburgh's own descriptions that the two species are probably allied, since apart from other features they both are said to possess a green gland in the axil of the lowest nerve on each side of the leaf. In his description of *F. polycarpa* Roxburgh likens his species in this respect to *F. laciniata*. There is, however, no *F. laciniata* either in Flora Indica or elsewhere, and a glance at the description and plate (in Wight's Icones) of *F. wassa*, with its leaves sometimes laciniate, suggests that Roxburgh originally named this species *F. laciniata* and afterwards changed the name to *F. wassa* forgetting, however, to make the corresponding alteration in his manuscript under *F. polycarpa*.

F. copiosa and *F. wassa* are put into different groups by Roxburgh on account of the receptacles being borne differently, but as *F. copiosa* may have its receptacles either axillary or on the older branches or trunk Roxburgh's segregation can scarcely be maintained on the original grounds alone.

For the moment, however, the descriptions and plates differ too much in other respects to justify uniting the two species. Merrill's identification of Robinson's specimens as *F. wassa* depends to a great extent on the identity of the native name given to the plants described by Rumphius and Roxburgh with that

given to Robinson's plant. Until we know, however, that the names "wassa" and "giho" are applied by the natives to one species of Fig only, we cannot be sure of the identity of the species concerned.

I am, therefore, maintaining the name *F. copiosa* Steud. for the present species, although if the two species were united *F. wassa* would have to be adopted in view of its priority.

Ficus Kajewskii Summerhayes, sp. nov.

Arbor parva, 10–15 m. alta. Ramuli teretes, graciles, leviter flexuosi, primo scabridulo-pilosi, demum glabri cortice brunneo vel cinereo-brunneo longitudinaliter ruguloso obtecti. Folia pro genere parva, petiolata, oblique ovata, oblongo-ovata, oblongo-lanceolata vel lanceolata, apice breviter obtuse vel rarius subacute acuminata, basi inaequaliter cuneata usque subcordata, usque 11 cm. longa et 5 cm. lata sed saepius satis minora, chartacea vel rarius subcoriacea, utrinque asperula, glabra, costa supra prominula subtus prominente, nervis lateralibus utrinsecus 4–6 curvatis subtus prominentibus juxta marginem arcuatim conjunctis, nervis tertiariis prominulis, rete venularum quadrato manifesto; petiolus gracilis vel subgracilis, 4–8 mm. longus, primo scabridule pilosus demum glaber, supra canaliculatus; stipulae lanceolatae, acutae, 2–3 mm. longae, extra adpresse pilosae vel fere glabrae. Receptacula axillaria, solitaria vel gemina, pedunculata, globosa vel subglobosa, 5–6 mm. longa, 6–8 mm. diametro, breviter scabrido-pilosula vel fere glabra, ostiolo parvo bracteis vix prominentibus, intus inter flores setis brevibus hyalinis numerosis instructa; pedunculus gracilis, 2–6 mm. longus, scabrido-pilosulus. supra medium vel apice bracteis tribus ovatis obtusis instructus. Flores ♀ sessiles vel rarius usque 1 mm. pedicellati, perianthii segmentis 4–5 lineari-oblongis vel oblongis obtusis vel subacutis superne ± coalitis ovarium includentibus glabris; ovarium sessile, 1–1.5 mm. longum, complanatum, obovoideum vel ellipsoideum, stylo laterali 0.6–1.2 mm. longo, stigmate minuto leviter dilatato. Flores ♂ et ♀ cecidiophori non visi.

E f a t e : Undine Bay, alt. 200 m., rain-forest, common, no. 216, April 27, 1928 (tree about 15 m. high; fruit red when ripe); Mt. McDonald, alt. 500 m., rain-forest, common, no. 233, April 28, 1928 (tree 15 m. high). E r o m a n g a : Dillon Bay, centre of island, alt. 400 m., rain-forest, common, no. 343, June 1, 1928 (small fig, 10 m. high, with very small straight trunk). A n e i t y u m : Anelgauhat Bay, alt. 34 m., rain-forest, common, no. 737 (type), Feb. 12, 1929 (small tree 10 m. high; leaves dark

green, midrib light yellow; fruit purple black when ripe).—Vernacular name "Neme-sue" (under no. 343).

The nearest relative of this species seems to be **F. Barclayana** Summerhayes, comb. nov. (*Covellia Barclayana* Miq., *Ficus Barclayi* Seem.), a native of Fiji. Although that species is placed by Miquel in sect. Covellia and the female flowers are drawn as possessing no perianth, *F. Barclayana* seems to me to belong more properly to sect. Sycidium. Seemann's dissections from specimens which seem identical with the type show the female flowers as possessors of typical Sycidium perianths. *F. Kajewskii* differs from the Fiji plant in its less hairy receptacles, which are however furnished with colorless setae inside, in the perianth being quite glabrous and in minor characters of the leaves. Both species have the rough leaves and the small rough axillary receptacles characteristic of sect. Sycidium.

Ficus trichoneura Summerhayes, sp. nov.

Arbor parva vel mediocris usque 15 m. alta; ramuli hornotini ± adpresse hirsuti, annotini glabrescentes, cortice leviter longitudinaliter sulcato castaneo-brunneo obtecti. Folia alterna, longiuscule petiolata, rhombeo- vel oblongo-elliptica vel ovata, superne late acutata apice ipso emarginato-obtusa, basi rotundata vel subrotundata, 5–14 cm. longa, 2–6 cm. lata, chartacea, supra glabra, laevia, siccitate griseo-viridia, subtus costa et nervis primariis praesertim infimis adpresse hirsutis demum glabrescentibus, ceterum glabra, pallide viridia, saepius albido-punctulata, costa et nervis supra prominulis subtus prominentibus, nervis primariis utrinsecus 8–10 infimis angulo acuto ceteris angulo circiter 60° e costa exeuntibus prope marginem arcuato-conjunctis, rete venularum crebro distincto; petiolus gracilis, 1–4 cm. longus, supra leviter canaliculatus, primo dense adpresse hirsutus, demum glabrescens, cortice ei caulis simili obtectus; stipulae lineari-lanceolatae, acutissimae, glabrae, castaneo-brunneae, cito deciduae. Receptacula axillaria, solitaria vel saepius gemina, alia flores ♂ et ♀ cecidiophoros, alia flores ♀ includentia, pedunculata, sphaeroidea vel subsphaeroidea, viridia, 6–7 mm. longa, 7–9 mm. diametro, glabra, umbilico prominente, ostiolo depresso, bracteis vix obviis, intus setis paucis longiusculis inter flores instructa; pedunculus falsus (stipes receptaculi) gracilis, 1–4 mm. longus, puberulus, basi bracteis tribus parvis ovatis obtusis 1 mm. longis instructus, pedunculo vero simili 0.5–5 mm. longo, totus pedunculus 4–8 mm. longus. Flores ♂ prope ostiolum, sessiles, perianthii segmentis 3–4 liberis lineari-lanceolatis antheram includentibus brunneis glabris; stamen 1, filamento antherae aequilongo. Flores

♀ cecidiophori sessiles, brunnei, perianthio irregulariter fisso segmentis saepius 2–3 lanceolatis ovario aequilongis glabris; ovarium compresse ellipsoideum vel ovoideum, circiter 1 mm. longum, stylo laterali brevi, stigmate breviter clavato. Flores ♀ sessiles, brunnei, perianthii segmentis tribus linearibus 1.25–.5 mm. longis; ovarium compresse reniforme, 1.5 mm. longum, rugulosum, stylo laterali, stigmate clavato ovarium paulo superante, bractea basali spathulato-lineari.

Banks Group: Vanua Lava, sea level, rain-forest, common, no. 417, July 6, 1928 (medium sized tree up to 15 m. high), and no. 426 (type) July 6, 1928 (small tree up to 6 m. high). Eromanga: Dillon Bay, sea level, rain-forest, common, no. 264, May 17, 1928 (smaller type of Fig averaging 10 m. high). Tanna: Lenakel, alt. 200 m., rain-forest, common, no. 89, March 5, 1928 (large tree 20 m. high); alt. 100 m., rain-forest soil, common, no. 23, Feb. 21, 1928 (tree 12–15 m. high; leaves dark green). Aneityum: Anelgauhat Bay, sea level, rain-forest, common, no. 711, Feb. 9, 1929 (Fig tree growing 20 m. high; fruit green when ripe, 6 mm. in diam.).—Vernacular name "Bongnute" (under no. 264).

This species is apparently one of the commonest Figs in the New Hebrides, as in addition to the above gatherings there are at Kew several more from the southern islands of the group. According to Miss L. E. Cheesman the species is also found in Malekula, which is quite probable, although I have not seen a specimen from that island. The species has been collected up to 300 m. altitude. There is also a specimen at Kew collected by Kajewski in the Santa Cruz Islands.

F. trichoneura is most closely allied to *F. chrysolaena* K. Schum., a native of New Guinea and the Solomon Islands, which differs in having the veins more hairy below while the lamina is also partly hairy, the receptacles larger and shortly pubescent, and the bracts immediately at the base of the receptacles so that there is no stipe. It is also interesting to note that our species very strongly resembles *F. adenosperma* Miq. which, however, by virtue of its hermaphrodite flowers is placed in sect. Palaeomorphe. Since both *F. trichoneura* and *F. chrysolaena* vary considerably from the normal type of sect. Sycidium it is possible that they are really types of sect. Palaeomorphe in which the hermaphrodite flowers have been lost. In this connection it is worthy of notice that in *F. adenosperma* wholly male flowers are present as well as hermaphrodite and gall flowers, the hermaphrodite flowers containing a properly developed gall ovary and an abortive stamen.

Sect. COVELLIA

Ficus verrucosa Vahl, Enum. II. 192 (1806).

Ficus septica Forster, Prodr. Fl. Ins. Austral. 76 (1786).—Non Burm. f.
Ficus casearia F. v. Mueller apud Bentham Fl. Austral. VI. 177 (1873).—Summerhayes in Jour. Arnold Arbor. X. 148 (1929).

Eromanga: Dillon Bay, alt. 300 m., rain-forest, common, no. 271, May 17, 1928 (Fig with single stem up to 15 m. high; leaves dark glossy green; fruit yellow when ripe). Aneityum: Anelgauhat Bay, sea level, rain-forest, common, no. 793, Feb. 20, 1929 (large tree 12 m. high; fruit 12 mm. long, flattened at both sides, cream-color when ripe).—Vernacular name "Ubariherhon" (under no. 271).

This species is widely spread from the New Hebrides to New Guinea and Australia. There are specimens at Kew from the Admiralty and Solomon Islands. It is closely allied to *F. leucantatoma* Poir.

Sect. EUSYCE

Ficus Moseleyana King in Ann. Bot. Gard. Calcutta, I. 144, t. 181 (1888).

Banks Group: Vanua Lava, sea level, sea shore, common, no. 433, July 7, 1928 (medium tree up to 15 m. high).

Previously known only from eastern Malaya.

Artocarpus incisa Linnaeus f., Suppl. 411 (1781).

Eromanga: Dillon Bay, common in rain-forest at sea level, no. 394, June 9, 1928 (large tree up to 20 m. high; the most useful tree of the islands as it supplies large quantities of fruit and the wood is used for canoes).—Also New Caledonia, Samoa, Society, Ellice, Gilbert, Marshall, Caroline, Mariana, Santa Cruz, Solomon, Bismarck and Admiralty Islands, New Guinea and Hawaii.—Vernacular name "Ne-marl."

URTICACEAE

Laportea crenulata (Roxb.) Gaudichaud in Arch. Mus. Nat. Paris, IX. 133, t. 2c, fig. 5 (1856).

Banks Group: Vanua Lava, common in rain-forest at sea level, no. 421, July 6, 1928 (large tree up to 15 m. high, leaves glossy above; bad as a stinging tree).—Also Bismarck Islands, New Guinea and Malaysia.

It seems that the plant found on Efate by Levat should be referred to this species and not to *L. photiniphylla*.

Elatostema macrophyllum Brongniart in Duperrey, Voy. Coquille 207, t. 45 (1829).

Aneityum: Anelgauhat Bay, common in rain-forest up to 450 m., no. **968** (coll. *J. P. Wilson*), Sept. 1929 (small shrub about 1.30 m. high; flowers small, white; fruit at base of flower, about 0.4 cm. in diam.; stem pithy).—Vernacular name "Ilbuvin."

Procris pedunculata Weddell in De Candolle, Prodr. XVI. pt. I. 191 (1869).

Aneityum: Anelgauhat Bay, common in rain-forest at 300 m., no. **852**, March 2, 1929 (plant up to 1 m. high; fruit with red pulp and white seeds).—Already found on Efate; also New Caledonia, Fiji, Samoa, Society, Marquesas, Marshall, Mariana, Solomon and Bismarck Islands and New Guinea.

Boehmeria anisoneura Guillaumin, sp. nov.

Arbor parva, trunco 15 cm. diam., ramis rufo-velutinis, foliis oppositis inaequalibus, uno valde asymmetrico ovato (usque ad 25 cm. × 10 cm.), petiolo 6–8 cm. longo, altero fere symmetrice ovato (usque ad 12 cm. × 8 cm.), petiolo circa 0.5 cm. longo, membranaceis margine a basi ad apicem dense serratis apice attenuatis vel longe acuminatis basi oblique rotundatis leviterque cordatis, nervis principalibus 3, uno in parte angustiore fere apicem attingenti, altero in parte latiore ad tertiam supremam partem vergente, secundariis a venorum exteriorum exteriore parte regulariter parallelis numerosis, a veno centrali ad partem latiorem arcuatis paucis, nervis valde reticulatis, pagina superiore hispido-scabra, inferiore velutina, petiolo velutino, stipulis intrapetiolaribus lanceolatis 2–3 cm. longis tarde deciduis, extra praecipue secundum lineam longitudinaliter centralem argenteo-hispidis. Flores albi, in axillis glomerati, glomerulis circa 1 cm. diam. multifloris, bracteis glabris, ♀ perigonio ore breviter 2–3-dentato extra hirsuto ellipsoideo, ovario styloque glabris.

Aneityum: west coast, common in rain-forest up to 600 m., no. **1005** (coll. *J. P. Wilson*), Sept. 1929 (small tree to 15 cm. in diam.; flowers very small, white; fruit very small, at base of petiole).—Vernacular name "Nowau."

A very remarkable species among those with axillary glomerules and opposite leaves. It seems nearest to *B. monticola* Bl. of Sumatra.

Boehmeria platyphylla (Buch-Ham.) D. Don, Prodr. Fl. Nep. 60 (1825).

Aneityum: west coast, common in rain-forest up to 450 m., no. **961** (coll. *J. P. Wilson*), Sept. 1929 (small tree to 15 cm. in diam.; flowers small; fruit very small).—Already found on Espiritu Santo; also New Caledonia, Australia (Queensland), Fiji, Samoa and Society Islands, New Guinea, Malaysia.—Vernacular name "Nahwai."

Cyphologus macrocephalus Weddell in Ann. Sci. Nat. sér. 4, I. 198 (1854).

Aneityum: Anelgauhat Bay, common in rain-forest at 300 m., no. 766, Feb. 14, 1929 (shrub up to 3.60 m. high; fruit light green).—Also Fiji, Samoa and Society Islands, Moluccas and Malaysia.

Pipturus albidus (Hook. & Arn.) A. Gray apud Mann in Proc. Am. Acad. Sci. VII. 201 (1867).

Tanna: Mt. Tokosh Meru, common in rain-forest at 1000 m., no. 148, March 15, 1928 (small plant 1 m. high on crest of the mountain).—Also New Caledonia, Society Islands, New Guinea and Hawaii.

Pipturus argenteus Weddell in DeCandolle, Prodr. XVI. pt. I, 235[19] (1869).

Aneityum: Anelgauhat Bay, common in rain-forest at sea level, no. 712, Feb. 9, 1929 (small tree up to 12 m. high; leaves dark green above, silvery beneath, with light pink petiole; fruit light green). Tanna: Lenakel, common in heavy rain-forest soil at sea level, no. 10, Feb. 20, 1928 (small tree up to 6 m. high; leaves dark green above, silvery underneath).—Already found on Aneityum, Erronan, Tanna and Efate; also Australia (Queensland, New South Wales), Fiji, Tonga, Society, Marquesas, Mariana and Bismarck Islands, New Guinea, Moluccas and Malaysia.

Pipturus repandus Weddell in Arch. Mus. Paris, VIII. 448 (1855).

Tanna: Mt. Tokosh Meru, common in rain-forest at 200 m., no. 144, March 14, 1928 (tree up to 20 m. high; natives use root for cleaning hair).—Also New Caledonia, Loyalty Islands, Malaysia and Hawaii.

Leucosyke capitellata Weddell in De Candolle, Prodr. XVI. pt. I. 235[27] (1869).

Aneityum: west coast, common in lower forest ranges up to 180 m., no. 963 (coll. *J. P. Wilson*), Sept. 1929 (small tree, trunk up to 0.3 m. diam., flowers yellow; fruit round, brown); Anelgauhat Bay, common in rain-forest at 60 m., no. 759, Feb. 13, 1929 (small tree up to 9 m. high; leaves silvery underneath, with brown-green veins). Efate: Undine Bay, common in rain-forest at 300 m., no. 227, April 27, 1928 (tree up to 10 m. high; leaves green above, silvery underneath).—Also Solomon Islands (?), Bismarck Islands, New Guinea, Moluccas and Malaysia.—Vernacular name "Niicki-fig" (under no. 963).

CASUARINACEAE

Casuarina equisetifolia Linnaeus, Amoen. Acad. IV. 143 (1759).—Forster, Char. Gen. 103, fig. 52 (1776).

Aneityum: Anelgauhat Bay, common on seashore, no. **697**, Feb. 4, 1929 (tall tree up to 20 m. high, common throughout the New Hebrides). Banks Group: Vanua Lava, common on seashore, no. **451**, July 9, 1928 (tree up to 20 m. high growing on the average much larger than the Queensland coastal "She-oak").—Already found on Aniwa; also New Caledonia, Australia (Queensland, North Australia), Fiji, Tonga, Cook, Society, Marquesas, Mariana, Solomon, Bismarck and Admiralty Islands, New Guinea, Malaysia.

ORCHIDACEAE

Determined by Oakes Ames

Corymborchis veratrifolia (Reinw.) Blume, Fl. Jav. nov. ser. I. 105, t. 43, fig. 1 (1858).

Tanna: no. **146** (see p. 127).

Malaxis neo-ebudica Ames in Jour. Arnold Arb. XIII. 128 (1932).

Tanna: no. **137** (see p. 128).

Malaxis xanthochila (Schltr.) Ames & Schweinfurth in Ames, Orch. VI. 73 (1920).

Aneityum: no. **837** (see p. 128).

Liparis condylobulbon Reichenbach f. in Hamb. Gartenz. XVIII. 34 (1862).

Eromanga and Banks Group: nos. **321** and **455** (see p. 129).

Dendrobium (§ Aporum) sp.

Efate: no. **190** (see p. 131).

Eria Kajewskii Ames in Jour. Arnold Arb. XIII. 135 (1932).

Aneityum: no. **820** (see p. 135).

Ceratostylis subulata Blume, Bijdr. 306 (1825).

Efate: no. **234** (see p. 138).

Earina Brousmichei Kränzlin in Lecomte Not. Syst. IV. 136 (1928).

Aneityum: no. **844** (see p. 138).

Appendicula reflexa Blume, Bijdr. 301 (1825).

Aneityum and Eromanga: nos. **915** and **326** (see p. 138).

Spathoglottis Petri Reichenbach f. in Gard. Chron. n. ser. VIII. 392 (1877).

Eromanga: no. **306** (see p. 140).

Saccolabium Kajewskii Ames in Jour. Arnold Arb. XIII. 141 (1932). Efate and Banks Group: nos. **205** and **448** (see p. 141).

ZINGIBERACEAE

Zingiber zerumbet Roscoe apud Smith, Exot. Bot. II. 105, t. 112 (1805); in Trans. Linn. Soc. VIII. 348 (1807).

Aneityum: Anelgauhat Bay, common in rain-forest at 180 m., no. **850**, March 2, 1929 (plant up to 1.5 m. high; flowers white).—Also New Caledonia, Australia (Queensland), Fiji, Samoa, Society, Marquesas, Mariana and Bismarck Islands, New Guinea, Malaysia and Hawaii.

Alpinia Blumei K. Schumann in Bot. Jahrb. XXVII. 282 (1900)?

Banks Group: Vanua Lava, common in rain-forest at sea level, no. **416**, July 5, 1928 (tall plant about 3 m. high, along water courses; flowers bright pink).

The characters agree well with the description of this Javanese species except that the inflorescence attains 14 cm., but the flowers are lacking and it is impossible to know the shape of the bractlet. In any case the plant belongs in the genus *Guillainia*.

MARANTACEAE

Donax arundastrum Loureiro, Fl. Cochin. 11. (1790).

Banks Group: Vanua Lava, common in swampy rain-forest at sea level, no. **420**, July 6, 1928 (plant up to 2 m. high with branches radiating from one node; flowers white to cream-colored; fruit 1.5 cm. in diam.).—Also in the Philippines and Asia.

AMARYLLIDACEAE

Crinum pedunculatum R. Brown, Prodr. Fl. Nov. Holl. 297 (1810).

Aneityum: Anelgauhat Bay, common along sea shore, no. **805**, Feb. 21, 1929 (large plant up to 1.5 m. high, growing close to the beaches; leaves numerous, long; flowers white).—Also New Caledonia, Australia (Queensland, New South Wales, South Australia), Tonga and Cook Islands, New Guinea, Moluccas and Malaysia?

TACCACEAE

Tacca pinnatifida Forster, Gen. Char. 70, t. 35 (1776).

Eromanga: Dillon Bay, common in rain-forest at 400 m., no. **345**, June 1, 1928 (plant up to 80 cm. high growing wild on all the islands; arrowroot is manufactured from the bulbs and has been a source of revenue for the mission stations).—Also New Caledonia, Loyalty Islands, Australia (Queensland, South Australia),

Fiji, Tonga, Samoa, Society, Marquesas, Ellice, Marshall, Caroline, Mariana, Solomon and Bismarck Islands, New Guinea, Malaysia and Hawaii.—Vernacular name "Yovoli."

DIOSCOREACEAE

Dioscorea bulbifera Linnaeus, Sp. Pl. 1033 (1753).

Aneityum: Anelgauhat Bay, common in rain-forest at sea level, no. **896**, March 11, 1929 (wild yam growing over the small trees; not edible).—Already found on Efate; also New Caledonia, Loyalty Islands, Australia (Queensland), Fiji, Tonga, Samoa, Society, Marquesas, Caroline and Mariana Islands, New Guinea, Moluccas, Malaysia and Hawaii.

Dioscorea nummularia Lamarck, Encyc. Méth. III. 231 (1789). ?

Eromanga: Dillon Bay, common in native gardens, rain-forest at sea level, no. **250**, May 15, 1928 (climbing on sticks placed by natives who take great care of its cultivation; this red yam is the chief food of natives).—Also Australia (Prince of Wales Island), Fiji, Society, Caroline and Bismarck Islands, New Guinea, Moluccas, Philippines.—Vernacular name "Loop."

It is strange that the collector indicates *D. nummularia* as the edible species and *D. bulbifera* as the wild species, and one may ask whether the labels have not been interchanged.

LILIACEAE

Smilax vitiensis A. De Candolle in De Candolle, Monogr. Phaner. I. 204 (1878).

Banks Group: Vanua Lava, common in rain-forest at 500 m., no. **483**, July 16, 1928 (vine growing over rain-forest trees; fruit purple to black when ripe).—Also Fiji and Bismarck Islands.

Smilax sp.

Aneityum: Anelgauhat Bay, common in rain-forest at 210 m., no. **819**, Feb. 28, 1929 (vine growing over rain-forest trees; fruit 1.3 cm. long, 1.5 cm. in diam., black when ripe).

Geitonoplesium cymosum A. Cunningham in Bot. Mag. t. 3131 (1832).

Aneityum: Anelgauhat Bay, common in rain-forest at sea level, no. **832**, Feb. 28, 1929 (vine growing over rain-forest trees; fruit 0.5 cm. long, 0.8 cm. in diam., black when ripe).—Also New Caledonia, Loyalty Islands, Australia (Queensland, New South Wales, Victoria), Norfolk Island, Fiji and Bismarck Islands and New Guinea.

Dianella ensifolia [A. P. DeCandolle in] Redouté, Lil. I. 1, t. 1 (1802).

Eromanga: Dillon Bay, common in poor red soil, open country at 400 m., no. 346, June 1, 1928 (plant about 1 m. high; flowers pale blue).—Also New Caledonia, Australia (Queensland, North Australia), Fiji, Tonga, Society, Caroline and Mariana Islands, New Guinea, Malaysia and Hawaii.—Vernacular name "Did-and-Did."

Dracaena sp.

Aneityum: Anelgauhat Bay, common in rain-forest at sea level, no. 881, March 6, 1929 (up to 6 m. high; fruit 2.5 cm. long, 3 cm. in diam.; black when ripe; leaves used for making grass skirts).

The leaves of the plant resemble exactly those of *D. aurantiaca* Wall. of the Philippines and Asia.

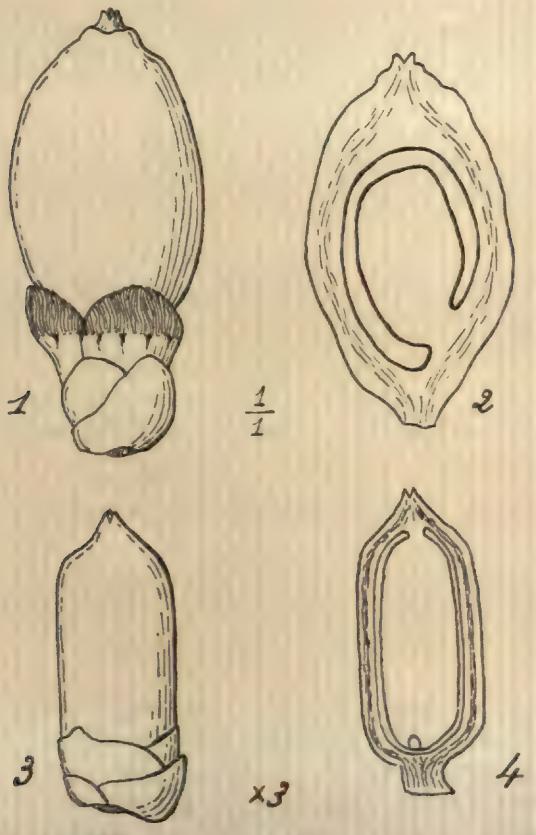

FIG. 1.—CHAMBEYRENIA sp.: 1. Fruit. 2. Longitudinal section of fruit. CYPHOPHOENIX sp.: 3. Fruit. 4. Longitudinal section of fruit.

PALMAE

Chambeyronia sp. aff. *C. macrocarpa* Vieill. Fig. 1: 1, 2

Banks Group: Vanua Lava, rare in rain-forest at sea level, no. 428, July 6, 1928 (Palm up to 15 m. high; fruit edible).

Cyphophoenix sp. nov. ? Fig. 1: 3, 4

Banks Group: Vanua Lava, common in rain-forest at 100 m., no. 465, July 11, 1928 (tall palm 15 m. high; fronds about 2 m. long).

The fruit resembles completely that of *C. elegans* H. Wendl. of New Caledonia, the only species of the genus, but differs in its smaller size (1.8 cm. × 0.4 cm.), its turbinate shape and its smooth pericarp.

Kajewskia aneityensis Guillaumin, gen. nov. et sp. nov. Fig. 2

Palma 20 m. alta, foliis ultra 4 m. longis pinnatisectis, segmentis lanceolatis (circa 60 cm. × 8 cm.) acuminatis in axilla subtusque ad costae basin brunneo-filamentoso-squamatis. Spadix valde

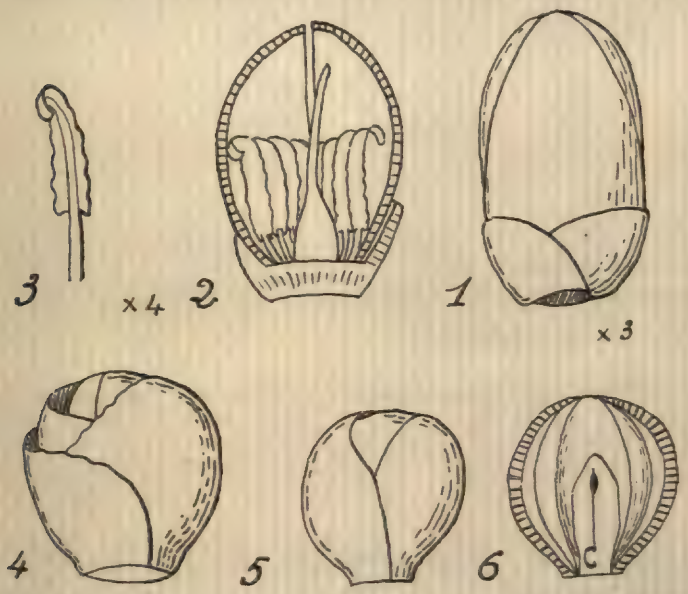

Fig. 2.—Kajewskia aneityensis Guillaumin: 1. Staminate flower. 2. Longitudinal section of staminate flower. 3. Stamen. 4. Pistillate flower. 5. Corolla. 6. Longitudinal section of pistillate flower.

ramosus, ramis angulosis brunneo-squamatis, floriferis circa 15 cm. longis valde sinuosis, floribus ♂ et ♀ intermixtis singulis vel 2-nis uno ♂ altero ♀, ♂ ellipsoideis (12 mm. × 7 mm.) vertice rotunda-

tis symmetricis, sepalis rotundatis ad 4 mm. longis imbricatis, petalis ellipticis apicem versus attenuatis crassis valvatis, staminibus ∞, antheris linearibus apice recurvis undulatis 4 mm. longis, loculis parallelis basi leviter divaricatis, filamentis duplo brevioribus connectivo nigro continuis, pistillodio basin versus incrassato in collum tenuem attenuato stamina superante, ♀ globosis (8 mm. diam.), sepalis laxis valde imbricatis ad 8 mm. longis ovato-rotundatis, petalis inclusis valde appresse cucullato intricatis 7 mm. longis ovato-rotundatis, staminodiis 0, ovario oblonge turbinato tertia suprema parte conice stigmatoso, ovulo 1 parietali ad loculi basin inserto.

Aneityum: Anelgauhat Bay, not common in rain-forest at sea level, no. **784**, Feb. 19, 1929 (large palm to 18 m. high; fronds up to 3.5 m. long; stamens white, anthers cream-colored).

Near *Actinokentia*, a genus represented only by *A. divaricata* Dammer (= *A. Schlechteri* Dammer) of New Caledonia, but differs in its much larger flowers resembling those of *Arenga*, not regularly arranged in three's (2 lateral and 1 central flower) and in the absence of the staminodes in the pistillate flower.

PANDANACEAE

Determined by U. Martelli

Pandanus Cominsii Hemsley in Hooker's Icon. Pl. XXVII. t. 2654 (1900).

Banks Group: Vanua Lava, common in rain-forest at 100 m., no. **471**, July 12, 1928 (up to 4 m. high, much smaller than its coastal relative; fruit red when ripe, on a cylindrical spike).—Also found in Solomon Islands.

Freycinetia tannaensis Martelli in Jour. Arnold Arb. XII. 269 (1930). Plate 43

Tanna: on Mt. Tokosh Meru, very common in rain-forest, at 800 m., no. **163**, March 15, 1928 (climbing up the trunks of trees).

ARACEAE

Epipremnum pinnatum (L.) Engler in Engler, Pflanzenr. IV. 23[B], p. 60 (Arac.) (1908).

Aneityum: Anelgauhat Bay, common in rain-forest at 210 m., no. **830**, Feb. 28, 1929 (climbing up the trunks of trees: fruit 10–15 cm., long).—Already found on Tanna; also in New Caledonia, Loyalty Islands, Australia (Queensland), Fiji, Tonga, Marshall and Bismarck Islands, New Guinea, Moluccas and Malaysia.

Freycinetia tannaensis Martelli
Photograph of type in the Herbarium Martelli

CYPERACEAE[1]

Pycreus polystachyus Beauvais, Fl. Owar. II. 48, t. 86 (1807).

E r o m a n g a : Dillon Bay, common in cleared rain-forest at sea level, no. **277**, May 19, 1928 (small sedge 30–40 cm. high).—Also New Caledonia, Australia (Queensland, New South Wales), Samoa, Cook and Bismarck Islands, New Guinea, Malaysia.—Vernacular name "Overi-car."

Kyllingia monocephala Rottboell, Descr. Ic. 13, t. 4, fig. 4 (1773).

E r o m a n g a : Dillon Bay, commonly growing in cleared rain-forest at sea level, no. **276**, May 19, 1928 (sedge 25–40 cm. high; macerated with leaves of "Denyung" (Cane grass) in cold water and drunk for spleen trouble; macerated with leaves of "Naivoss," "Tomirirri" and "Nesivinesip" (shrub) in cold water and drunk by women in state of pregnancy for good health).—Already found on Aneityum, waste place (*MacGillivray*, no. 53, December 1858 [unpublished locality]) and on Efate; also New Caledonia, Australia (Queensland, New South Wales), Norfolk Island, Fiji, Tonga, Samoa, Cook, Society, Caroline, Mariana, Santa Cruz, Solomon and Bismarck Islands, New Guinea and Malaysia.—Vernacular name "Polell."

Fimbristylis communis Kunth, Enum. Pl. II. 234(1837).

E r o m a n g a : Dillon Bay, common in open grass country at 300 m., no. **318**, May 28, 1928 (sedge about 50–75 cm. high; plaited together by women for grass dresses).—Already found on Aneityum, swamp (*MacGillivray*, no. 24, Oct. 1858 [unpublished locality]).—Also New Caledonia, Australia (Queensland, New South Wales, North Australia), Tonga, Cook, Society, Mariana and Bismarck Islands, New Guinea and Malaysia.—Vernacular name "Farll."

Lepidosperma sp. cf. *L. elatius* Labill. of Australia (Victoria, Tasmania).

T a n n a : Mt. Tokosh Meru, common in rain-forest at 1000 m., no. **155**, March 15, 1928 (sedge on very top of the mountains).

Cladium Milnei C. B. Clarke in Kew Bull. Add. ser. 8, p. 46 (1908).

E r o m a n g a : Dillon Bay, common in poor red soil, bracken country, no. **327**, May 29, 1928 (about 1 m. high; seed bright brown).—Already found on Aneityum.[2]—Vernacular name "Did-and-did."

[1] To the plants cited in my "Liste des plantes connues [des Nouvelles Hébrides] (in Bull. Soc. Bot. France LXXIV. 709, 1927) the following should be added: *Fimbristylis monostachya* Hassk., Aneityum, open place (*MacGillivray*, no. 44), Feb. 1859; *Scirpus mucronatus* L., Eromanga, stream (*MacGillivray*, n. 7), Sept. 1879; *Rynchospora aurea* Vahl, Aneityum, swamps (*MacGillivray*, no. 28), Oct. 1878 (inedited).

[2] Omitted from my "Liste des plantes connues [des Nouvelles Hebrides]. (Bull. Soc. Bot. France LXXIV. 709. 1927).

GRAMINEAE

Determined by A. S. HITCHCOCK

Isachne distichophylla Munro in Jour. Bot. VII. 178 (1869), nom. nud.; Hillebrand, Fl. Hawaiian Isl. 504 (1888).

T a n n a : Mt. Tokosh Meru, common in rain-forest at 1000 m., no. 147, March 15, 1928 (small grass right on the top of Tokosh Meru).—Also in Hawaii.

Brachiaria subquadriparia (Trin.) Hitchcock in Lingnan Sci. Jour. VII. 214 (1931).

E r o m a n g a : Dillon Bay, common in cleared rain-forest at sea level, no. 278, May 19, 1928 (short grass 30–40 cm. high; one of the commonest grasses in the islands, growing among the cocoanuts after the scrub has been felled; the natives say it is introduced).—Also Australia (Queensland, South Australia), Mariana and Bismarck Islands.—Vernacular name "Noth-lor-si."

Brachiaria ambigua (Trin.) A. Camus in Lecomte, Fl. Gén. Indo-Chine, VII. 433 (1922).

E r o m a n g a : Dillon Bay, common in clearings in rain forest at sea level, no. 279, May 19, 1928 (grass about 60 cm. high; introduced).—Already found in Aneityum; also New Caledonia, Fiji, Samoa, Cook, Mariana and Solomon Islands.

Syntherisma microbachne (Presl) Hitchcock in Mem. Bishop Mus. Honolulu, VIII. 177 (1922).

E r o m a n g a : Dillon Bay, common in rain-forest clearings at sea level, no. 280, May 19, 1928 (grass 0.60–1 m. high; cattle are not very fond of it).—Also in South America.—Vernacular name "Nofle-fule."

Oplismenus compositus (L.) Beauvois, Essai Agrost. 54 (1812).

E r o m a n g a : Dillon Bay, common in rain-forest clearing at sea level, no. 281, May 19, 1928 (grass about 80 cm. high in the scrub).—Already found on Aneityum, Epi and Espiritu Santo; also New Caledonia, Loyalty, Fiji, Society, Gambier and Marquesas Islands and Hawaii.—Vernacular name "Nooh-nempeli."

Cenchrus calyculatus Cavanilles, Ic. v. 39. t. 463 (1799).

E r o m a n g a : Dillon Bay, common in rain-forest at sea level, no. 358, June 4, 1928 (tall grass about 1.25 m. high; seeds troublesome to clothing).—Already found on Espiritu Santo; also New Caledonia, Loyalty, Fiji, Cook, Society, Gambier, Caroline and Mariana Islands and Hawaii.—Vernacular name "Ularhai."

Coix lacryma-jobi Linnaeus, Sp. Pl. 972 (1753).

T a n n a : Lenakel, common in rain-forest clearings at 200 m., no. **118**, March 6, 1928 (weed in native gardens).—Already found on Tanna; also New Caledonia, Queensland, Fiji, Tonga, Samoa, Society, Marshall, Solomon, Bismarck Islands, New Guinea and Malaysia.

Miscanthus sinensis Andersson in Oefv. Svensk. Vetensk.-Akad. Stockh. 1855, p. 166.

T a n n a : Lenakel, common in rain-forest soil at 100 m., no. **39**, Feb. 22, 1928 (tall cane 4–6 m. high; used by natives for arrows and roofs of houses).—Already found in Aneityum; also New Caledonia, Fiji, Tonga, Cook, Society Island and Malaysia.

Centotheca latifolia Trinius, Fund. Agrost. 141 (1820).

E r o m a n g a : Dillon Bay, common in semi-cleared rain-forest at sea level, no. **338**, May 29, 1928 (chewed by natives and applied to burns).—Already found in Aneityum and Tanna; also New Caledonia, Australia (Queensland, North Australia), Fiji, Tonga, Samoa, Cook, Society, Marquesas, Caroline, Mariana, Bismarck and Admiralty Island, New Guinea and Malaysia.—Vernacular name "Now-now."

CONIFERAE

Podocarpus imbricatus Blume, Enum. Pl. Javae, 89 (1827).

Podocarpus cupressinum R. Brown apud Mirbel in Mém. Mus. Hist. Nat. Paris, XIII. 75 (Geogr. Conif.) (1825), nomen.—R. Brown apud Bennett, Pl. Jav. Rar. 25, t. 10 (1838–52).

A n e i t y u m : Anelgauhat Bay, common in rain-forest at 150 m., no. **849**, Aug. 2, 1929 (up to 12 m. high; seed about 1 cm. long, 1 cm. in diam. resting on a fleshy growth 0.5 cm. long).—Already found on Aneityum; also Fiji Islands, Malaysia and Philippines.

Agathis obtusa (Lindl.) Masters in Jour. Roy. Hort. Soc. Lond. XVI. 197 (1892).

A n e i t y u m : Anelgauhat Bay, common in rain-forest at 150 m., no. **706**, Feb. 5, 1929 (large tree up to 40 m. high on well drained slopes where the soil is intensely volcanic and red, especially typical of the country where the Kauri is found on the islands; this specimen is remarkable for the small size of the cones and the irregular sunken places on their surface; the best timber tree for boat building in the southern hemisphere); common in rain-forest at 60 m., no. **760**, Feb. 13, 1929 (giant tree; cones malformed); common in rain-forest at 100 m., no. **707**, Feb. 19, 1929.—Already found on Aneityum and Eromango.—Determined by E. H. Wilson.

CYCADACEAE

Cycas circinalis Linnaeus, Sp. Pl. 1188 (1753).

Eromanga: Dillon Bay, common in rain-forest and open country at 300 m., no. 400, June 8, 1928 (Cycad up to 10 m., high; fronds up to 2 m. long; fruit yellow, borne in fours).—Already found in the New Hebrides; also New Caledonia, Loyalty Islands, Australia (North Australia), Fiji, Tonga, Caroline, Mariana, Solomon, Bismarck and Admiralty Islands, New Guinea, Malaysia.—Vernacular name "No-mall."

This is perhaps the same species as that named *C. neo-caledonica*, by Linden (without description).

PTERIDOPHYTA

Determined by E. B. Copeland

HYMENOPHYLLACEAE

Trichomanes Boryanum Kunze, Farnkräuter, 237 (1847).

Aneityum: Anelgauhat Bay, common in rain-forest at 150 m., no. 883, March 7, 1929 (about 15 cm. high). Banks Group: Vanua Lava, common in rain-forest at 400 m., in rain-forest where the rain-fall reaches 250 inches per annum, no. 461, July 10, 1928.

Trichomanes Bauerianum Endlicher, Prodr. Fl. Norf. 17 (1833).

Aneityum: Anelgauhat Bay, common in gullies in rain-forest at 600 m., no. 864, March 5, 1929 (growing in shade at high altitudes). Tanna: Mt. Tokosh Meru, common in rain-forest at 800 m., no. 164, March 15, 1928.

Trichomanes meifolium Bory apud Willdenow, Spec. Pl. V. 509 (1810).

Aneityum: Anelgauhat Bay, common in rain-forest mountains at 750 m., no. 867, March 5, 1929.

Trichomanes sp.

Banks Group: Vanua Lava, common on mountains in rain-forest at 300 m., where the rain-fall reaches about 250 inches per annum, no. 454, July 12, 1928.

The specimen which is sterile may belong to *T. aphlebioides* Christ.

Hymenophyllum formosum Brackenridge in Bot. Wilkes U. S. Expl. Exp. XVI. 268, t. 32, fig. 3 (1854).

Aneityum: Anelgauhat Bay, common in rain-forest at 750 m., nos. 868 and 871[a], March 5, 1929 (small fern growing upon rain-forest trees).

CYATHEACEAE

Balantium, an *B. dubium?*

Aneityum: Anelgauhat Bay, common in rain-forest at 150 m., no. 885, March 9, 1929 (large tree fern; trunk up to 1.5 m. high; fronds up to 2.8 m. long).

Balantium stramineum (Labill.) Diels in Engler & Prantl, Nat. Pflanzenfam. I.–4, p. 119 (1899).

Aneityum: Anelgauhat Bay, common in rain-forest at 210 m., no. 859, March 4, 1929 (fronds up to 2.8 m. long; main stem growing close to the ground).

Cyathea laciniata Copeland in Univ. Calif. Publ. Bot. XII. 389 (1931).

Aneityum: Anelgauhat Bay, common in rain-forest at 600 m., no. 876, March 5, 1929 (small tree fern up to 3.1 m. high; fronds up to 1.5 m. long).

Cyathea leucolepis Mettenius in Ann. Mus. Bot. Lugd.-Bat. I. 56 (1863).

Aneityum: Anelgauhat Bay, common in rain-forest at 210 m., no. 861, March 4, 1929 (tree fern up to 6 m. high; fronds up to 3 m. long).

Cyathea medullaris (Forst.) Swartz in Jour. Bot. Schrad. 1800, pt. II. 94 (1801).

Aneityum: Anelgauhat Bay, common in rain-forest up to 210 m., no. 857, March 4, 1929 (tree fern up to 9 m. high; fronds up to 3 m. long). Tanna: Lenakel, common in rain-forest at 150 m., no. 54, Feb. 24, 1928 (tree fern up to 8 m. high; fronds 3–3.5 m. long).

POLYPODIACEAE

Dryopteris rubrinervis (Mett.) Christensen, Ind. Fil. 289 (1905).

Tanna: Lenakel, common in rain-forest soil at 200 m., no. 61, Feb. 24, 1928 (large fern in gullies; fronds about 2 m. long).

Probably identical with *D. urophylla* Christens.

Dryopteris urophylla (Wall.) Christensen, Ind. Fil. 299 (1905).

Aneityum: Anelgauhat Bay, common in rain-forest at 210 m., no. 858, March 4, 1929 (large fern; trunk small at base up to about 0.3 m. high; fronds up to 2.1 m. long).

Dryopteris sp.

Aneityum: Anelgauhat Bay, common in rain-forest at 210 m., no. 860, March 4, 1929 (main stem not more than 0.3 m. high; fronds up to 2.1 m. long).

Dryopteris sp.

T a n n a : Lenakel, common in heavy rain-forest at sea level, no. 5, Feb. 20, 1929 (fern growing in clumps, 0.6–1 m. high).

Dryopteris sp.

T a n n a : Lenakel, common in heavy rain-forest at sea level, no. 5, Feb. 20, 1928 (fern growing in clumps, 0.6–1 m. high).

Polystichum aristatum (Forst.) Presl, Tent. Pterid. 83 (1863).

A n e i t y u m : Anelgauhat Bay, common in dense shade in rain-forest at 300 m., no. 847, March 2, 1929 (fronds up to 1 m. long).

Campium lonchophorum (Kunze) Copeland, comb. nov.

Acrostichum lonchophorum Kunze, Farnkräuter, pl. 2 (1840).

A n e i t y u m : Anelgauhat Bay, common in rain-forest at 450 m., no. 893, March 9, 1929 (fronds up to 0.60 m. long).

Dipteris conjugata Reinwardt in Syll. Pl. Ratisb. II. 3 (1824).

A n e i t y u m : Anelgauhat Bay, common on banks of rain-forest streams at 150 m., no. 916, March 17, 1929. E r o m a n g a : Dillon Bay, common in rain-forest at 400 m., no. 325, May 29, 1928 (growing in clumps, about 60 cm. high).—Vernacular name "Nenn-parr" (under no. 325).

Oleandra ciliata Klotzsch apud Kuhn in Linnaea, XXXVI. 126 (1869).

A n e i t y u m : Anelgauhat Bay, common at 750 m., no. 874, March 5, 1929 (fern climbing up trees; stem dark brown).

Humata pusilla (Mett.) Carruthers in Seemann, Fl. Vit. 335, (1873).

A n e i t y u m : Anelgauhat Bay, common in rain-forest at 150 m., no. 855, March 4, 1929 (small climbing fern just appearing outside the moss on trees).

Davallia solida Swartz in Jour. Bot. Schrad. 1800, pt. II. 87 (1801).

A n e i t y u m : Anelgauhat Bay, common in rain-forest at sea level, no. 835, March 1, 1929 (fern with an underground rhizome, sometimes growing on the trunks of trees).

Microlepia speluncae (L.) Moore, Ind. Fil. XCIII. (1857).

T a n n a : Lenakel, common in heavy rain-forest soil at sea level, no. 6, Feb. 20, 1928 (80 cm. to 1.25 m. high).

Tapeinidium tenue (Brack.) Copeland in Bernice P. Bishop Mus. Bull. LIX. 69 (1929).

A n e i t y u m : Anelgauhat Bay, common in rain-forest at

150 m., no. **894**, March 9, 1929 (fern growing on ground; fronds up to 0.6 m. long).

Dennstaedtia samoensis (Brack.) Moore, Ind. Fil. 307 (1861).

Aneityum: Anelgauhat Bay, common in rain-forest at 150 m., no. **884**, March 9, 1929 (tree fern with small trunk about 0.45 m. high; fronds up to 3 m. long).

Lindsaya decomposita Willdenow, Sp. Pl. v. 425 (1810).

Banks Group: Vanua Lava, common in rain-forest at 700 m., no. **458**, July 10, 1928.

Athyrium accedens (Bl.) Milde in Bot. Zeit. 1870, p. 353.

Tanna: Lenakel, common in rain-forest at 150 m., no. **133**, March 8, 1928 (about 1 m. high).

Athyrium sp.

Aneityum: Anelgauhat Bay, common in rain-forest at 600 m., no. **877**, March 5, 1929 (tree fern about 2.5 m. high; fronds up to 2 m. long).

Athyrium sp.

Tanna: Lenakel, common in rain-forest soil at 200 m., no. **55**, Feb. 24, 1928 (large fern; fronds about 2–2.5 m. long).

Asplenium affine Swartz in Jour. Bot. Schrad. 1800, pt. II. 56 (1801).

Aneityum: Anelgauhat Bay, common in rain-forest at 150 m., no. **888**, March 9, 1929 (fern growing on trees or on the ground; fronds 1 m. long).

Asplenium amboinense Willdenow, Sp. Pl. v. 303 (1810).

Aneityum: Anelgauhat Bay, common in rain-forest at 210 m., no. **838**, March 2, 1929 (small-leaved fern growing on small trees in dense shade).

Asplenium brachycarpum (Mett.) Kuhn in Linnaea, XXXVI. 104 (1869).

Aneityum: Anelgauhat Bay, common in rain-forest at 600 m., no. **878**, March 5, 1929 (small tree fern up to 1.5 m. high; trunk 45 cm. high; fronds up to 1 m. long).

Asplenium laserpitiifolium Lamarck, Encycl. Méth. II. 310 (1786).

Aneityum: Anelgauhat Bay, common in rain-forest at 300 m., no. **848**, March 2, 1929 (fronds up to 1.5 m. long). Tanna: Lenakel, common in rain-forest at 100 m., no. **71**, March 1, 1928 (about 1 m. high).

Asplenium nidus Linnaeus, Sp. Pl. 1079 (1753).

Banks Group: Vanua Lava, common in rain-forest at sea level, no. 444, July 12, 1928 (growing on trees, common throughout the group).

Asplenium sp.

Aneityum: Anelgauhat Bay, common in rain-forest at 300 m., no. 887, March 9, 1929 (growing sometimes on trees, sometimes on rocks; fronds up to 0.6 m. long).

Blechnum gibbum (Labill.) Mettenius in Ann. Sci. Nat. sér. 4, XV. 68 (1861).

Aneityum: Anelgauhat Bay, common in rain-forest at 210 m., no. 856, March 4, 1929 (small tree fern up to 1.5 m. high, bearing distinct sterile and fertile fronds; fronds up to 1.3 m. long). Tanna: Ikiti, common along rain-forest streams at 100 m., no. 171, March 16, 1928 (small tree fern up to 1.5 m. high; growing in clumps with 10 or more stems in one clump).

Blechnum opacum (Baker) Mettenius in Ann. Sci. Nat. sér. 4, XV. 69 (1861).

Aneityum: Anelgauhat Bay, common in rain-forest at 600 m., no. 879, March 5, 1929 (small fern bearing distinct sterile and fertile fronds).

Blechnum Patersoni (R. Br.) Mettenius, Fil. Hort. Bot. Lips. 64, t. 4, figs. 4–10 (1856).

Tanna: Mt. Tokosh Meru, common in rain-forest at 300 m., no. 156, March 15, 1928 (about 1 m. high).

Sphenomeris chusana (L.) Copeland in Bernice P. Bishop Mus. Bull. LIX. 69 (1929).

Aneityum: Anelgauhat Bay, common in rain-forest at 180 m., no. 891, March 9, 1929 (growing on the ground; fronds up to 0.65 m. long).

Aspleniopsis decipiens Mettenius apud Kuhn, Chaetopt. 325 (1882).

Aneityum: Anelgauhat Bay, common in rain-forest at 750 m., no. 870, March 5, 1929 (small fern up to 15 cm. high).

Cheilanthes hirsuta (Poir.) Mettenius in Abhandl. Senckenb. Naturf. Ges. v. 25, n. 17 (1859).

Notholaena hirsuta (Poir.) Desvaux in Jour. de Bot. Appl. I. 93 (1813).

Aneityum: Anelgauhat Bay, common in the open along seashore at sea level, no. 928, March 17, 1929.

Adiantum aneitense Carruthers in Seemann, Fl. Vit. 346 (1873).
Aneityum: Anelgauhat Bay, common in rain-forest at 150 m., no. 889, March 9, 1929 (fronds up to 0.65 m. long).

Adiantum diaphanum Blume, Enum. Pl. Jav. 215 (1828).
Tanna: Lenakel, common on sides of gullies in rain-forest at 200 m., no. 56, Feb. 24, 1928 (very small fern).

Pteris comans Forster, Fl. Ins. Austr. Prodr. 79 (1786).
Aneityum: Anelgauhat Bay, common on banks of creeks in rain-forest at sea-level, no. 719, Feb. 9, 1929 (fronds up to 3 m. long).

Pteris ensiformis Burmann, Fl. Ind. 230 (1768).
Aneityum: Anelgauhat Bay, common in rain-forest at 150 m., no. 904, March 11, 1929 (up to 0.6m. high).

Pteris tripartita Swartz in Jour. Bot. Schrad. 1800, pt. II. 67 (1801).
Aneityum: Anelgauhat Bay, common along streams in rain-forest at 150 m., no. 892, March 9, 1929 (fronds up to 2.8 m. long).

Vittaria lineata (L.) Smith in Mem. Acad. Sci. Turin, v. 421, t. 9, fig. 5 (1793).
Aneityum: Anelgauhat Bay, common in rain-forest at 150 m., no. 934, March 17, 1929 (up to 0.3 m. high; growing on bark of trees).

Hymenolepis mucronata Fée, Gen. Fil. 82 (1850–52).
Aneityum: Anelgauhat Bay, common in rain-forest at 210 m., no. 890, March 9, 1929 (climbing upon trees).

Polypodium blechnoides (Grev.) Hooker, Sp. Fil. IV. 180 (1862).
Aneityum: Anelgauhat Bay, common in rain-forest near the summit of the mountain at 450 m., no. 886, March 9, 1929 (small fern).

Polypodium scolopendria Burmann, Fl. Ind. 232 (1768).
Eromanga: Dillon Bay, common in rain-forest at 300 m., no. 380, June 7, 1928 (small fern).—Vernacular name "Nemkar woramel."

Selliguea feeioides Copeland in Bernice P. Bishop Mus. Bull. LIX. 94 (1929).
Aneityum: Anelgauhat Bay, common in rain-forest at 750 m., no. 875, March 5, 1929 (climbing upon trees). Tanna:

Mt. Tokosh Meru, common in rain-forest at 800 m., no. 165, March 15, 1928 (climbing along the trunks of trees).

Cyclophorus acrostichoides (Forst.) Presl, Epimel. Bot. 130 (1849).

Aneityum: Anelgauhat Bay, common in rain-forest at sea level, no. 714, Feb. 9, 1929 (growing on tree trunks and climbing by means of runners; common throughout the islands). Tanna: Lenakel, common in rain-forest at 200 m., no. 101, March 5, 1928 (parasitic fern).

Drynaria rigidula (Sw.) Beddome, Ferns Br. Ind. t. 314 (1869).

Aneityum: Anelgauhat Bay, common in rain-forest at sea level, no. 834, March 1, 1929 (growing on trees; stem shielded by a brown heart-shaped growth).

GLEICHENIACEAE

Gleichenia Brackenridgei Fournier in Ann. Sci. Nat. sér. 5, XVIII. 269 (1873).

Aneityum: Anelgauhat Bay, common in rain-forest at 750 m., no. 873, March 5, 1929 (large fern up to 1.8 m. high; a much smaller form is common on the waste-lands).

Gleichenia linearis (Burm.) Clarke in Trans. Linn. Soc. ser. 2, I. (Bot.) 428 (1880).

Tanna: Mt. Tokosh Meru, common in rain-forest at 800 m., no. 161, March 15, 1928.

Gleichenia oceanica Kuhn, Verh. Zool.-Bot. Ges. Wien, XIX. 583 (1869).

Tanna: Mt. Tokosh Meru, common in rain-forest at 800 m., no. 160, March 15, 1928.

SCHIZAEACEAE

Schizaea dichotoma (L.) Smith in Mem. Acad. Sci. Turin, V. 422, t. 9, fig. 9 (1793).

Aneityum: Anelgauhat Bay, common in rain-forest at 150 m., no. 918, March 17, 1929 (small plant up to 0.60 m. high). Eromanga: Dillon Bay, common in rain-forest at 300 m., no. 286, May 23, 1928 (plant with single stem 40 cm.); common in poor red soil, bracken country at 400 m., no. 355, June 1, 1928 (small plant 20 cm. high).—Vernacular name "Nempari" (under no. 286).

According to the collector's note under no. 286 this plant has a remarkable history; if worn when a war was on in old heathen

days it was a sign that the wearer was a non-combatant and was respected as such; the name "Nempari" means peace-maker.

Lygodium reticulatum Schkuhr, Kryptog. Gew. I. 139, t. 139 (1809).

Aneityum: Anelgauhat Bay, common in rain-forest at sea level, no. **882**, March 7, 1929 (climbing as high as 9 m. into trees). Eromanga: Dillon Bay, common in poor red soil, bracken country, at 300 m., no. **303**, May 24, 1928 (climbing fern with a twining stem often 3–4 m. long; used by natives as a twine for house-building).—Vernacular name "Nor-rep" (under no. 303).

OSMUNDACEAE

Leptopteris Wilkesiana (Brack.) Christ, Farnkr. d. Erde, 334 (1897).

Aneityum: Anelgauhat Bay, common in rain-forest at 750 m., no. **869**, March 5, 1929 (small tree fern up to 1.8 m. high; fronds up to 1 m. long).

OPHIOGLOSSACEAE

Ophioglossum pendulum Linnaeus, Sp. Pl. ed. 2, II. 1518 (1763).

Aneityum: Anelgauhat Bay, common in rain-forest at 210 m., no. **825**, Feb. 28, 1929 (parasitic fern hanging down from a large *Asplenium*). Tanna: Lenakel, not common in rain-forest at 100 m., no. **139**, March 8, 1928 (parasite on a large Banyan Fig).

LYCOPODIACEAE

Lycopodium cernuum Linnaeus, Spec. Pl. 1103 (1753).

Aneityum: Anelgauhat Bay, common in shade of rain-forest at 150 m., no. **854**, March 4, 1929 (climbing Lycopod). Tanna: Mt. Tokosh Meru, common on shaded banks in rain-forest at 900 m., no. **158**, March 15, 1928. Efate: Undine Bay, common in shade of bracken on high open hills at 250 m., no. **224**, April 27, 1928.

Lycopodium oceanianum Herter in Bot. Jahrb. XLIII. beibl. 98, p. 52 (1909).

Efate: Undine Bay, Mt. McDonald, common in rain-forest at 600 m., no. **239**, April 29, 1928 (parasite on trees).—Vernacular name "Tassel Fern."

Lycopodium Phlegmaria Linnaeus, Sp. Pl. 1101 (1753).

Aneityum: Anelgauhat Bay, common in rain-forest at 210 m., no. **824**, Feb. 28, 1929 (growing upon trees).

Lycopodium squarrosum Forster, Fl. Ins. Austr. Prodr. 86 (1786).

Aneityum: Anelgauhat Bay, common in rain-forest at 300 m., no. 843, March 2, 1929 (spore cases light yellow before they burst, easily discernible at end of stem).

PSILOTACEAE

Psilotum complanatum Swartz, Syn. Fil. 188, 414 (1806).

Aneityum: Anelgauhat Bay, common in rain-forest at 150 m., no. 919, March 17, 1929 (parasite, up to 1 m. high; growing from holes and in forks of trees; sporangia cream-white, minute). Eromanga: Dillon Bay, common in rain-forest at 200 m., no. 377, June 7, 1928 (parasite hanging down from trees).—Vernacular name "Ami-ghokul" (under no. 377).

Psilotum nudum (L.) Grisebach in Abh. Ges. Wiss. Göttingen, VII. 278 (1857).

Tanna: Lenakel, rare in rain-forest at 150 m., no. 134, March 8, 1928 (parasite growing in crevices of roots of Banyan trees).

ADDITIONS

Vol. XII. 230

Heritiera litoralis Dryand.—Add: Already found on Efate.

Vol. XII. 260. Add under SAMYDACEAE:

Casearia Melistaurum Sprengel, Syst. II. 354 (1825).

Aneityum: Anelgauhat Bay, common in rain-forests up to 500 m., no. 981 (coll. J. P. Wilson), Sept. 1929 (small tree, trunk about 45 cm. diam.; flowers green, fruit clusters at base of leaves).—Also New Caledonia.—Vernacular name "Nidu-pualau."

Vol. XIII. 23. Add before CORDIA MYXA:

Cordia subcordata Lamarck, Tabl. Encycl. Méth. I. 421, n. 1899 (1791).

Efate: Fila Island, Vila, common on sea coast, no. 184, April 13, 1928 (tree about 8 m. high; natives say the fruit is eaten).—Already found on Efate; also New Caledonia, Loyalty Islands, Australia (Queensland), Society and Marquesas Islands, New Guinea and Malaysia.

MUSÉUM NATIONAL D'HISTOIRE NATURELLE,
PARIS.

CONTRIBUTION TO THE FLORA OF THE NEW HEBRIDES AND SANTA CRUZ ISLANDS

ORCHIDS COLLECTED BY S. F. KAJEWSKI IN 1928 AND 1929

OAKES AMES

A. GUILLAUMIN, in his enumeration of the species that comprise the flora of the New Hebrides, included less than forty representatives of the Orchidaceae. With the exception of *Corymborchis*, *Bulbophyllum*, and *Habenaria* which is represented in the tropics of both hemispheres and, if broadly interpreted, extends into the temperate zones, all of the genera enumerated by Guillaumin are paleotropical.

Collections recently made by S. F. Kajewski in 1928 and 1929 for the Arnold Arboretum have increased substantially the orchid flora of the New Hebrides and the adjacent islands of the Santa Cruz Group. Several of the genera found by Kajewski are additions to the region and ten of the species are new. Unfortunately some of Kajewski's material was collected without flowers and admits only of tentative or suggestive identification.

Two courses are open to the student of a flora which is but little known and which shows a close relationship to the floras of distant regions: he may disregard slight differences between species in hand and species from other localities, and recast published descriptions so that they will include his material, or he may throw emphasis on slight differences and, in anticipation of more intensive exploration and a wider knowledge of the flora, interpret specific characters in a very narrow sense. In the following treatment I have adopted the latter course, being prompted to do so by the conviction that an erroneous extension of range for a genus or species is more detrimental to scientific progress than the increase of synonyms.

Corymborchis veratrifolia (Reinw.) Blume, Fl. Jav. nov. ser. I. 105, t. 43, fig. 1 (1858).

Tanna: Mt. Tokosh Meru, terrestrial, in rain-forest at 200 m., no. 146, March 14, 1928 (pretty, white-flowered ground orchid, 1 m. high; sweetly scented).—Already found on Espiritu Santo (Campbell).

The flowers are somewhat smaller than in typical material. A still smaller flowered plant with narrower leaves, collected by Dr. R. Morrison on Efate, August 20, 1896, appears to belong here. (Herb. Kew.). It is probable that the specimens examined rep-

resent a new species, but until more material is available it would be unwise to separate Kajewski's specimens from *C. veratrifolia*. *C. veratrifolia* has already been reported as a native of the New Hebrides. It is a widely distributed species ranging from India to New Guinea.

Malaxis neo-ebudica Ames, sp. nov.

Herba terrestris. Caules elongati, foliosi. Folia ovato-lanceolata, acuminata, in petiolum sulcatum contracta. Pedunculus elongatus. Bracteae inflorescentiae anguste lineares. Racemus cylindraceus, elongatus, multiflorus, floribus flavidis. Pedicellus cum ovario quam bractea subtendens paulo brevior. Sepala lateralia elliptica, uninervia, obtusa, in sicco pellucida. Sepalum dorsale anguste ellipticum, valde obtusum, uninervium. Petala lineari-oblonga, obtusa, uninervia. Labellum trilobatum, lobi laterales post columnam in auriculas elongatas producti, lobus medius plus minusve triangulus, haud retusus, utrinque paucidentatus.

Stem up to 12 cm. long, ascending, bearing about 10 membranaceous leaves. Leaves variable, the lowermost ones much the smallest, uppermost leaves about 13 cm. long, up to 3 cm. wide, contracted at base into broad sheathing petioles, lanceolate, acuminate-acute. Peduncle slender, conspicuously angulate when dry, together with the raceme about 14 cm. long. Raceme slender, about 10 cm. long, many-flowered. Bracts of the inflorescence elongated, linear-lanceolate, about 7 mm. long, exceeding the flowers. Pedicellate ovary about 5 mm. long. Flowers yellow. Lateral sepals 2 mm. long, about 1 mm. wide, elliptical, obtuse, 1-nerved, spreading. Upper sepal similar, but slightly narrower. Petals about 2 mm. long, linear-oblong, obtuse, 1-nerved. Labellum 3-lobed, including the lateral lobes 3.5 mm. long. Lateral lobes auriculate, about 2 mm. long, narrowly triangular, acute or obtuse, twice or thrice longer than the column. Middle lobe 1.5 mm. long from tip to point of attachment, triangular, terminating in a bluntly triangular lobule on either side of which there are 2–3 irregular teeth.

T a n n a : Lenakel, small plant growing in shade of large trees; flowers yellow; alt. 100 m. in rain-forest. No. 137 (type in Herb. Ames no. 36366), March 8, 1928.

The nearest ally of this species appears to be *M. bancana* (Ridl.) O. Ktze. from which it differs in the structure of the lip. *M. oculata* (Reichb. f.) O. Ktze. is also a closely allied species, but differs vegetatively from *M. neo-ebudica*.

Malaxis xanthochila (Schltr.) Ames & Schweinfurth in Ames, Orch. VI. 73 (1920).

Microstylis xanthochila Schlechter in K. Schumann & Lauterbach, Nachtr. Fl. Deutsch. Schutzgeb. 102 (1905).

Aneityum: Anelgauhat Bay, common in rain-forest at sea level, no. **837**, March 1, 1929 (small plant up to 1 ft. high; flowers yellow). —Also New Guinea.

Two specimens which are referable to this species, one collected by Dr. R. Morrison on Aneityum at Anelgauhat in June 1896, the other collected by L. Cheeseman at South West Bay, Malekula in January 1930, are preserved in the Kew Herbarium. Although the basal auricles of the lip in the Malekula plant are longer than is typical, it agrees in essential characters with *M. xanthochila*.

Malaxis lunata (Schltr.), comb. nov. (*Microstylis lunata* Schlechter in Fedde Rep. Spec. Nov. IX, 162 [1911]) differs from *M. xanthochila* in the basal auricles of the labellum and in the spatulate petals. The type specimen of *M. lunata* was collected by Dr. Morrison on Aneityum near Anelgauhat.

Liparis condylobulbon Reichenbach f. in Hamb. Gartenz, XVIII: 34 (1862).

Liparis confusa J. J. Smith, Fl. Buitenz. VI. (Orch. Jav.) 275 (1905).

Eromanga: Dillon Bay, common in rain-forest at 400 m., no. **321**, May 29, 1928 (growing on trees thickly shaded from the sun). Banks Group: Vanua Lava, common in rain-forest at 350 m., no. **455**, July 10, 1928 (orchid growing in dense shade on small tree in gully; perianth organs small, outer ones pale green, inner ones brown).—Vernacular name "Ute-melme-pohl" (under no. 321).

In the Kew Herbarium there are five specimens representing this species, obtained in Aneityum in 1896 by Dr. R. Morrison. This is one of the most widely distributed species of the genus, being very common in the Philippines, Sumatra, Java, Celebes, Borneo and New Guinea.

Coelogyne asperata Lindley in Jour. Hort. Soc. IV. 221 (1849).

Santa Cruz Group: Vanikoro, common in rain-forest at sea level, no. **679**, December 4, 1928 (beautiful, large-leaved orchid common on trees in Vanikoro; leaves dark green; flower yellow-cream, orange center; most beautiful of Vanikoro orchids).

The specimen collected was in bud, and not wholly satisfactory for identification, but there is sufficient evidence to warrant referring it to the widespread *C. asperata*, a species which ranges from the Malay Peninsula to Sumatra, Borneo, the Philippine Islands and New Guinea.

Coelogyne lamellata Rolfe in Kew Bull. 1895, 36.

Santa Cruz Group: Vanikoro, common in rain-forest at sea level, no. **687**, December 5, 1928 (large-leaved orchid common in the scrub on large trees; flower light yellow-green).

Pholidota imbricata Lindley in Hook. Exot. Fl. II. t. 138 (1825).

Santa Cruz Group: Vanikoro, common in rain-forest at sea level, no. 681, December 4, 1928 (orchid common on trees close to salt water creek; fruit yellow, brown when ripe). Eromanga: Dillon Bay, common orchid on trees in gullies in rain-forest at 300 m., no. 390, June 8, 1928 (capsules opened when ripe and the seeds put on the natives' faces as a substitute for the face powder of commerce).

The material, on which the identification of no. 681 rests, is devoid of flowers. It is highly probable that this material is conspecific with *P. grandis* Kraenzl. apud Guillaumin in Bull. Soc. Bot. France, LXXVI. 301 (1929), non Ridl. in Jour. Str. Br. Roy. Asiat. Soc. XLIX. 32 (1907). Kraenzlin described *P. grandis* with the aid of fruiting specimens to which only vestiges of the flowers adhered. In view of the occurence of what appears to be *P. imbricata* on Eromanga, and taking into consideration the extensive range of this species, from India to Burma, Assam, Siam, Malay Peninsula, China, Sumatra, Java, the Philippine Islands, Celebes, Borneo and New Guinea, I suspect that *P. grandis* Kraenzl. is referable to it.— Vernacular name "Utnimpoll" (under no. 390).

Pseuderia vanikorensis Ames, sp. nov.

Caules elongati, vaginis foliorum omnino obtecti, plus minusve flexuosi. Folia disticha, anguste lanceolata, usque ad apicem attenuata, acuta. Vaginae foliorum tubulatae, arcte adpressae. Racemi pauciflori, laterales. Sepala lateralia falcata, valde carnosa, leviter carinata. Sepalum dorsale spathulatum, concaviusculum, plus minusve rigidum, prope apicem carinatum. Petala oblongo-ligulata, apicem versus paulo latiora, obtusa, uninervia. Labellum ellipticum, subacutum, dense papillosum; callus linearis in disco decurrens. Columna carnosa, arcuata, in pedem brevem producta, labello articulata.

Stems 5–6 dm. long, slender, about 6 mm. in diameter, concealed by the sheathing bases of the leaves, more or less flexuose. Leaves numerous, distichous, 13–14 cm. long, about 2.5 cm. wide, 2–2.5 cm. apart, narrowly lanceolate, tapering gradually to an acute tip, rounded at the base and contracted into a short sulcate petiole. Petiole articulate with a tubular sheath. Racemes produced on the upper part of the stem, distichous, 2.5–3 cm. long. Bracts of the raceme lanceolate, rigid, shorter than the pedicels, blackish when dry. Pedicel with the ovary about 8 mm. long, glabrous, slender. Lateral sepals shorter than the dorsal sepal, 8 mm. long, about 2.5–3 mm. wide above the middle, very fleshy, rigid, falcate-oblong, obtuse, deflexed, carinate along the middle nerve on the outer surface.

Dorsal sepal 1 cm. long, 2 mm. wide above the middle, concave-spatulate, obtuse, conspicuously carinate near the tip on the outer surface, arcuate. Petals about 7.5 mm. long, 1.5 mm. wide, oblong-ligulate, obtuse, slightly broader near the tip than at the base, 1-nerved, slightly curved, fleshy. Labellum about 5 mm. long, hardly 4 mm. broad at the middle, elliptic, subacute, densely papillose, margin ciliolate. Disc with a fleshy keel extending from the base of the labellum almost to the apex on the inner surface; keel sulcate at the base. Column 5 mm. long, arcuate, produced at base into a short foot with which the labellum is articulated.

Santa Cruz Group: Vanikoro, in rain-forest at 150 m., no. 669 (type in Herb. Ames, no. 37190), December 3, 1928 (large climbing orchid hanging from rain-forest trees; leaves light green and glossy; flowers purple splashed with yellow).

In general facies this species closely resembles *Pseuderia frutex* Schltr. but differs in the form of the labellum.

Dendrobium (§ Aporum) sp.

Efate: Fila Island, Vila, common on rocky beach, no. 190, April 14, 1928 (small orchid growing on large rocks close to salt water).

The specimens are in fruit and indeterminable. Vegetatively the plants resemble closely *Dendrobium ventricosum* Kraenzl. from the Philippines.

Dendrobium Goldfinchii F. v. Mueller in Wing's South. Sci. Rec. (Jan. 1883).

Santa Cruz Group: Vanikoro, common at sea level, no. 636, November 20, 1928 (growing on rain-forest trees).—Already found on Aurora (*Im Thurn*, no. 341).—Also New Guinea and Admiralty Islands.

Dendrobium Kajewskii Ames, sp. nov.

Caules elongati, foliosi. Folia coriacea, elliptica vel elliptico-oblonga, apice inaequaliter bilobata. Pedunculi validi, elongati. Racemi multiflori. Sepala lateralia anguste triangularia, undulata, mentum formantia. Sepalum dorsale simile. Petala ligulata. Labellum trilobatum; lobi laterales rotundati, verrucosi; lobus medius ovatus; discus tricarinatus. Columna sectionis.

Roots elongated, about 2 mm. in diameter, whitish. Stems about 2.5 dm. or more tall, jointed, the upper internodes swollen; nodes 3–3.5 cm. apart. Leaves coriaceous, 5–11 cm. long, 2.5–3 cm. wide, elliptic to elliptic-oblong, unequally bilobed at the apex, contracted at base into closely appressed complanate sheaths,

only the uppermost leaves persisting at anthesis. Peduncles including the raceme elongated, up to 4 dm. long, 3 mm. or more in diameter, rigid, obliquely ascending, produced opposite the leaves, paucibracteate below the racemes. Bracts tubular, closely appressed, scarious. Racemes many-flowered, about 2 dm. long. Bracts of the raceme scale-like, much shorter than the pedicels. Pedicels slender, ascending, with the ovary 2.5 cm. long. Flowers large and showy. Lateral sepals 2.2 cm. long, about 5 mm. wide, narrowly triangular, undulate margined, acute, forming with the elongated foot of the column a subacute mentum. Upper sepal about 2 cm. long, 7 mm. wide, oblong-lanceolate, acute, 5-nerved, undulate margined. Petals ligulate, about 2.8 cm. long, 4 mm. wide, undulate margined. Labellum 2.5 cm. long, about 1.5 cm. wide, 3-lobed; lateral lobes rounded in front, rugulose or verrucose on the inner surface, about 1.5 cm. long; midlobe hardly 1 cm. long, 6 mm. wide, ovate, acute, undulate margined. Disc provided with three thickened keels. Column including the foot 1.5 cm. long, free portion 5 mm. long.

Santa Cruz Group: Vanikoro, common in rain forest, no. **638a** (type in Herb. Ames, no. 37111) and **638b,** November 20, 1928 (common orchid in the scrub on mangroves).

Under no. 638, Kajewski collected a series of specimens which differed from one another in floral characters and appeared to be separable. To these specimens he assigned the numbers 638, 638a and 638b. Number 638 is referable to *Dendrobium macranthum* A. Rich. Numbers 638a and 638b are conspecific differing from one another only in the color of the flowers and in slight differences in the form of the midlobe of the labellum. In 638a the prevailing color is yellow with purple lines, the labellum being greenish-yellow with purple striations. In 638b the sepals and petals are dull purple on the inner surface with bright yellow margins, while the labellum is bright yellow-green with purple lines and dots.

Dendrobium Kajewskii differs from *D. macranthum* in the undulate sepals and the very different labellum. From the closely allied *D. conanthum* Schltr., it differs chiefly in lacking supplementary carinae on the disc of the labellum and in having the lateral lobes verrucose or rugulose on the inner surface.

Dendrobium macranthum A. Richard, Sert. Astrol. 15, t. 6 (1832).

Santa Cruz Group: Vanikoro, common in rain-forest, no. **638,** November 20, 1928 (common orchid both in the scrub and on mangroves). This species was originally found on Vanikoro Island. —Also Samoa. The flowers are somewhat smaller than in typical *D. macranthum.*

Dendrobium (§ Dendrocoryne) **macrophyllum** A. Richard, Sert. Astrol. 22, t. 9 (1834).

Santa Cruz Group: Vanikoro, common in rain-forest at sea level, no. 637, November 20, 1928 (a common orchid; flower yellow with purple spots, very pretty).—Also New Guinea, Java and the Philippine Islands.

Dendrobium separatum Ames, sp. nov.

Caules elongati, validi, foliosi. Folia disticha, oblongo-lanceolata, apice inaequaliter bilobata, acuta, in sicco chartacea. Racemi laterales, plus minusve decemflori. Flores congesti, aurantiaci. Sepala lateralia oblonga, subacuta, mentum elongatum formantia. Sepalum dorsale oblongum, prope apicem angustatum, subacutum vel obtusum. Petala margine minute erosa, elliptico-lanceolata, obtusa vel subacuta, concaviuscula, uninervia. Labellum elongatum, simplex, infra medium leviter constrictum, superne in laminam oblongo-ellipticam productum, lamella transversa ornatum; lamella denticulata. Columna generis.

Stems up to 1 m. long, stout, leafy, concealed by the sheathing bases of the leaves, yellow after the fall of the leaves, deeply sulcate in dried specimens. Leaves spreading, 1.5–2 dm. long, 1.9–2.5 cm. wide, oblong-lanceolate, tapering to an acute unequally bilobed tip; internodes about 2.5 cm. long. Peduncles lateral on defoliated stems, including the raceme about 2 cm. long, produced at the nodes, rather fleshy, ascending or at right angles with the stem. Racemes about 1.5 cm. long, about 2 cm. in diameter, bearing ten or more orange flowers. Bracts of the raceme about 3 mm. long, narrowly lanceolate, acute, rigid. Flowers 1.5 cm. long, fleshy. Lateral sepals 1.4 cm. long including the mentum, 2.5 mm. wide, oblong, subacute, strongly concave, fleshy. Upper sepal 5 mm. long, oblong, narrowed to a rounded or subacute apex, strongly concave. Mentum about 9.5 mm. long, forming a blunt spur which is open in front. Petals 5 mm. long, about 2 mm. wide, elliptic-lanceolate, obtuse, with an erose margin, 1-nerved. Labellum 1.3 cm. long, slightly constricted below the middle, simple, 3 mm. wide above the middle, dilated upward forming an oblong-elliptic smooth lamina with the apical margin slightly inrolled, traversed, where it is constricted, by a fleshy retrorse plate which is minutely denticulate. Column including the foot 11 mm. long, fleshy.

Santa Cruz Group: Vanikoro, in rain-forest on giant Kauri at 350 m., no. 503 (type in Herb. Ames 37154), September 9, 1928 (straggling orchid up to 1 m. long, hanging in strings; flowers orange; found only on old stems).

This species has the general facies of *Dendrobium triviale* Kraenzl. but differs in the structure of the labellum and in having the transverse plate or lamella on the disc distinctly erose on the upper edge. The transverse lamella which serves as a dividing wall between the basal and apical parts of the labellum suggests the specific name of the plant.

Dendrobium vanikorense Ames, sp. nov.

Planta *D. acuminatissimo* habitu omnino congruens. Caules pergraciles, elongati. Folia disticha, linearia, acuta. Flores singuli, e nodis superioribus exorientes. Sepala lateralia anguste triangularia, acuta, mentum obtusum formantia. Petala linearia, usque ad apicem attenuata. Labellum anguste ellipticum, margine denticulato vel breviter fimbriato; callus angustus prope basim stat. Columna generis.

Stems up to 1 m. long, about 1.5 mm. in diameter, yellowish, concealed by the tubular sheaths with which the leaves are articulated. Leaves distichous, 8–11 cm. long, about 3 mm. wide, tapering gradually to an acute tip, linear-triangular, about 12 mm. apart. Inflorescence breaking through the leaf-sheaths opposite the leaves, 1-flowered, alternating on the upper part of the stem. Peduncle 6 mm. long, subtended by a closely appressed complanate bract about 5 mm. long. Lateral sepals 12–15 mm. long, about 3 mm. wide above the mentum, narrowly triangular, acute, forming an obtuse mentum 4 mm. long. Upper sepal 14–16 mm. long, similar to the laterals, subcaudate at the tip. Petals 12–15 mm. long, about 1 mm. wide near the base, linear, tapering gradually to the acute caudate tip, 3-nerved. Labellum simple, 11 mm. long, 4–5 mm. wide, elliptical with a shortly fringed or denticulate margin, upper surface thickly studded with simple or several-toothed, complanate processes, and provided near the base with an elongated central callus 4 mm. long. Column fleshy, stout, including the foot 6 mm. long.

Santa Cruz Group: Vanikoro, common in rain-forest at 50 m., no. **663** (type in Herb. Ames, no. 37191), November 28, 1928 (orchid up to 1 m. long, hanging down from the rain-forest trees; flower creamy yellow tinged with purple); poor red soil in rain-forest at 50 m., no. **657**, November 25, 1928 (a common orchid growing on small trees; flowers whitish); a sterile specimen which is vegetatively similar to no. **663**.

In general habit this species resembles *D. acuminatissimum* Lindl. from which it differs chiefly in having a simple lip. *D. indragiriense* Schltr. and *D. holochilum* Schltr. are closely allied species but differ both vegetatively and florally from *D. vanikorense*.

Eria Kajewskii Ames, sp. nov.

Radices fibratae, pubescentes. Pseudobulbi cauliformes, clavati, bracteis vaginantibus omnino obtecti. Folia prope apicem pseudobulbi conferta, oblonga, utrinque attenuata, apice inaequaliter bilobata. Pedunculi e parte superiore pseudobulbi exorientes, foliis multo breviores, glabri. Bracteae inflorescentiae in sicco brunneae, ellipticae. Pedicellus cum ovario gracilis, elongatus. Sepala lateralia anguste triangularia, acuta, mentum formantia. Sepalum dorsale simile. Petala oblongo-lanceolata, acuta. Labellum ovatum, margine irregulariter dentatum; discus glaber, prope basim bicallosus. Columna generis.

Roots fibrous, elongated, branching, finely pubescent. Pseudobulbs stemlike, 14–17 cm. long, clavate, when dry 7 mm. in diameter near the base, up to 11 mm. in diameter near the summit, concealed by brownish tubular closely appressed sheaths, the upper portion bearing about 5 more or less crowded leaves. Leaves 11.5–17 cm. long, 1.5–2 cm. wide, oblong, narrowed toward the ends, unequally bilobed at the apex. Peduncles arising from the upper part of the pseudobulb, interspersed among the leaves, about 9 cm. long, floriferous almost to the base. Flowers about 15 in a loose raceme. Floral bracts elliptic, brownish when dry, about 5 mm. long. Pedicel with the ovary about 1 cm. long, slender. Lateral sepals 11 mm. long, about 3 mm. wide at the base, narrowly triangular, acute, forming with the foot of the column a short obtuse mentum, 3-nerved; mentum 2 mm. long. Upper sepal 11 mm. long, about 2 mm. wide, oblong, acute, 3-nerved. Petals 9–10 mm. long, 2.5 mm. wide near the base, oblong-lanceolate, acute, 3-nerved, the outer nerves branched. Labellum 5 mm. long, about 2.5 mm. wide, rather fleshy, smooth, ovate, acute or subacute, margin with several blunt teeth on either side above the middle, 3-nerved with the outer nerves branching, bicallose near the base; calli abbreviated, one on each outer nerve. Column including the foot 5 mm. long.

Aneityum: Anelgauhat Bay, common in rain-forest at 200 m., no. **820** (type in Herb. Ames, no. 37850) (small orchid growing on trees; flowers inconspicuous).

Eria Kajewskii is closely allied to *E. retroflexa* Lindl. which it resembles closely in habit, but it is clearly distinguishable from that species and from all close allies in having the margin of the labellum bluntly dentate above the middle.

Eria vanikorensis Ames, sp. nov.

Caules elongati, erecti, vaginis foliorum omnino obtecti. Folia disticha, oblonga, utrinque attenuata, quam racemus longiora,

dense fusco-villosa, in petiolum vaginantem contracta. Racemi pauciflori, rubro-villosi. Bracteae inflorescentiae dense rufo-villosae, anguste ovatae, rigidae. Flores tomento rufo vestiti. Sepala lateralia triangulari-lanceolata, valde incrassata, intus et extus dense rufo-villosa, mentum obtusum formantia. Sepalum dorsale triangulari-lanceolatum. Petala oblonga, obtusa, extus dense rufo-villosa, leviter concava. Labellum prope apicem conspicue constrictum lobum transverse ellipticum vel reniformem formans, per lobum medium callo prominenti ornatum, inferne usque ad basim attenuatum; discus intus villosus, per medium 4-nervius. Columna generis.

Stems up to 1 m. long, concealed by the cylindrical foliar sheaths with which the leaves are articulated; sheaths 1.5–3 cm. long, densely covered with brownish, more or less matted hairs. Leaves distichous, up to 12.5 cm. long, 1.7–2.5 cm. wide, oblong-lanceolate, coriaceous, densely pubescent above, covered beneath with reddish appressed hairs. Racemes 5 or more, produced on the upper part of the stem, situated opposite the leaves, about 3.5 cm. long with a cupuliform sheath at the base. Rachis of the raceme densely reddish villose. Bracts subtending the pedicels about 1 cm. long, rigid, covered with reddish hairs. Ovary sessile, up to 2 cm. long, covered with reddish hairs. Flowers about 1 cm. long. Lateral sepals 1 cm. long, about 5 mm. wide near the base, triangular-lanceolate, acute, covered inside and out with bristle-like reddish hairs, fleshy, rigid, forming a prominent obtuse mentum. Upper sepal about 1 cm. long, similar to but narrower than the laterals. Petals 8 mm. long, 1.5 mm. wide, linear-oblong, rounded at the tip, sparsely pubescent inside, conspicuously hairy on the outside, mid nerve prominent. Labellum about 1 cm. long, 3 mm. wide, constricted 2 mm. below the apex forming a terminal reniform or transversely elliptical lobe; lamina oblong, contracted toward the base, ornamented inside and out with long closely appressed or slightly spreading reddish hairs; disc 4-nerved, ecarinate, with a short fleshy callus extending along the middle of the terminal lobe. Column characteristic of the genus.

Santa Cruz Group: Vanikoro, common in rain-forest, alt. 50 m., no. 512 (type in Herb. Ames no. 37110), September 20, 1928.

Allied to *E. iodantha* Schltr. from which it differs in the structure of the lip.

Mediocalcar vanikorense Ames, sp. nov.

Herba epiphytica. Radices dense pubescentes. Rhizoma validum, elongatum, arcte vaginatum, vaginis brunneis obtectum.

Pseudobulbi obpyriformes, in sicco valde sulcati, monophylli, statu juvenili vaginis vestiti. Folium variabile, 3.5–7.5 cm. longum, 1–1.7 cm. latum, valde coriaceum, oblongum vel oblanceolato-oblongum, apice tridentatum. Pedunculi uniflori ut videtur, singuli vel bini, folium aequantes vel breviores, plus minusve 4 cm. longi, paucibracteati, bracteis acuminatis. Flos 1 cm. longus, aurantiacus. Sepala cupulam formantia, ovata usque ad medium cohaerentia. Petala lineari-lanceolata, trinervia. Labellum prope medium valde calcarato-saccatum, ovato-acuminatum. Columna valida, labello brevior.

Rhizome rather stout, elongated, when young concealed by brownish tubular bracts, those subtending the pseudobulbs broadly ovate, chartaceous. Roots fibrous, elongated, branching, densely pubescent. Pseudobulbs 1–1.5 cm. long, obpyriform, longitudinally sulcate, monophyllous. Leaf extraordinarily variable, coriaceous, 3.7–7.5 cm. long, 1–1.7 cm. wide, oblong or oblong-oblanceolate, tapering gradually to a blunt bilobed apex, the midnerve extended into an apicule that almost equals the lobes in length. Peduncles single or geminate, shorter than or equalling the leaf, including the pedicellate ovary 2.5–4 cm. long, one-flowered, slender, only one peduncle floriferous at a time. Pedicel and ovary 1–1.5 cm. long, subtended by a scale-like acuminate bract. Flower urceolate, 1 cm. long, orange with the tip of the sepals yellow. Sepals similar, ovate-lanceolate, about 4 mm. wide at the point of union, free portion about 4 mm. long, united for more than half their length, the lateral ones forming a protuberant blunt mentum. Petals free, about 9.5 mm. long, hardly 2 mm. wide, linear-lanceolate, acute, 3-nerved. Labellum about 9 mm. long, parallel with the column, erect, with a rounded blunt sac near the middle; lamina ovate, acuminate-acute from a broad base. Column 6 mm. long.

Santa Cruz Group: Vanikoro Island, common on large trees at 50 m., no. 641 (type in Herb. Ames no. 37194), November 22, 1928. Also from the New Hebrides, Eromanga, Peak south of Dillon Bay, Dr. R. Morrison, August 5, 1896 (Herb. Kew). N. E. Traitor's Head, summit of old crater growing on rotten trunk, 2,400 feet alt., L. Cheeseman, no. 71 (Herb. Kew). Aneityum, Peak of Ithumu, Dr. Morrison, June 30, 1896 (Herb. Kew).

The genus *Mediocalcar* has not been reported heretofore from the New Hebrides or from the Santa Cruz Group. *M. vanikorense* is an ally of *M. bulbophylloides* J. J. Sm. differing from it in the widely separated pseudobulbs, larger leaves and in the color of the flowers. *Mediocalcar* is essentially New Guinean with very few outlying species. *M. ponapense* Schltr., from the Caroline

Islands, one of the few species reported from beyond New Guinea, differs from *M. vanikorense* in being much more robust, with larger pseudobulbs and dissimilar leaves.

Ceratostylis kaniensis Schlechter in Fedde Rep. Spec. Nov. Beihefte I. 245 (1912).

Santa Cruz Group: Vanikoro, common in rain-forest at 150 m., no. 575, November 6, 1928 (a plant found on a large Kauri tree).—Also New Guinea.

Ceratostylis subulata Blume, Bijdr. 306 (1825).

Efate: Undine Bay, common in rain-forest at 500 m., no. 234, April 28, 1928 (growing on bark of tree).—Also Java, Sumatra, Malay Peninsula, Assam.

The material studied lacks flowers and leaves. In general aspect the plant resembles *C. kaniensis* Schltr.

Earina Brousmichei Kraenzlin in Lecomte, Notulae Syst. IV. 136 (1928).

Aneityum: Anelgauhat Bay, common in rain-forest at 1000 feet, no. 844, March 2, 1929 (orchid growing on rain-forest trees; flowers white).—Also New Caledonia.

Kajewski's specimen differs from the type in being taller with much longer leaves. A flowerless plant from Efate, Undine Bay collected by Dr. Morrison in August 1896 appears to belong here (Herb. Kew).

Appendicula reflexa Blume, Bijdr. 301 (1825).

Aneityum: Anelgauhat Bay, common in poor red soil country at 500 feet, no. 915, March 17, 1929 (ground orchid 2 ft. high; flower white and green). Eromanga: Dillon Bay, common in poor red soil, bracken country, no. 326, May 29, 1928 (orchid growing on ground in shade of bracken and stunted brush; flower white).—Also Sumatra, Borneo, Celebes, and the Malay Peninsula.—Vernacular name "Orvum-nge-nompull" (under 326).

Appendicula vanikorensis Ames, sp. nov.

Herba gracilis. Caules vaginis foliorum omnino obtecti. Folia disticha, lanceolato-linearia, acuminata, apice rotundato-bilobulata, basi amplectentia. Inflorescentiae omnino laterales. Sepala lateralia late triangularia, trinervia, mentum obtusum formantia. Sepalum dorsale anguste ellipticum. Petala oblongo-lanceolata, valde obtusa, uninervia. Labellum simplex, carina hippocrepiformis instructum.

Stems slender, 1.5 dm. long in the fragments that were collected, probably attaining a height of 25 or 30 cm., entirely concealed by the

sheathing tubular bases of the leaves, flexuose. Leaves distichous, 3.5–5.5 cm. long, 8–15 mm. wide, about 1 cm. apart, narrowly lanceolate, bluntly bilobed at the tip with the midnerve projecting between the lobes, obliquely ascending. Inflorescences opposite the leaves, breaking through the tubular sheaths with which the leaves are articulated, about 1 cm. long, several-flowered. Bracts of the inflorescence about 3 mm. long, rigid, lanceolate. Lateral sepals about 3 mm. long including the blunt mentum, about 2 mm. wide at the base, strongly concave, broadly triangular, ending in a much thickened tip, 3-nerved. Upper sepal about 2.5 mm. long, approximately 1 mm. wide, narrowly elliptical, obtuse, 3-nerved, thickened at the apex, strongly concave. Petals 2 mm. long, 1 mm. wide, oblong-lanceolate, rounded at the apex, usually 1-nerved. Labellum 3 mm. long, 2 mm. wide, simple, lightly saccate at the broad base, in front of the sac expanded into a more or less elliptical obtuse lamina with an apical callus; sac with a large callus in the center; callus transversely elliptical with the ends continued into thickened keels. Column including the foot 2 mm. long, rostellum bifid.

Santa Cruz Group: Vanikoro, in rain-forest at 300 m., no. 594 (type in Herb. Ames, no. 37193), November 11, 1928 (orchid growing on rocks in a gully with water running around them; flowers greenish white).

In general aspect this plant resembles *A. anceps* Bl. but is dissimilar from it in the structure of the lip. *A. reflexa* Bl. is also a close ally but different from *A. vanikorensis* chiefly in the shape of the petals.

Calanthe Vaupeliana Kraenzlin in Notizbl. Bot. Gart. Berlin, XLIV. 111 (1907).

Santa Cruz Group: Vanikoro, common in rain-forest at 800 m., no. 599, November 11, 1928 (a ground orchid a meter high, found growing at high altitudes; flower beautiful, white, length of flower stalk 70 cm.).—Also Samoa.

Three specimens from the New Hebrides, collected on Aneityum in June 1896 by Dr. Morrison, are preserved in the Kew Herbarium. One of these specimens from Anelgauhat is described as having had yellow flowers, another specimen from ranges above Anelgauhat collected on June 4, 1896 is said to have had white flowers. Structurally the plants collected by Kajewski on Vanikoro and by Morrison on Aneityum are similar and agree in essential characters with *C. Vaupeliana*. The apical lobe of the labellum is variable. In the type it is oblong; in Morrison's specimens it is strongly dilated from the base. Kajewski's specimen, with regard

to the lip, is almost intermediate between Vaupel's Samoan plants and Morrison's plants from Aneityum.

Spathoglottis Petri Reichenbach f. in Gard. Chron. n. ser. VIII. 392 (1877).

Eromanga: Dillon Bay, common in red soil, bracken country at 300 m., no. 306, May 24, 1928 (ground orchid 1.5 m. high with pretty pale puce flowers).—Vernacular name "Lar-ver-ae."

In the Kew Herbarium there are three specimens from the New Hebrides, that are referable to *S. Petri*. Two of these were collected by Dr. R. Morrison on Aneityum near Anelgauhat in 1896. The third one was collected in March 1930 on Eromanga by L. Cheeseman (no. 14).

Spathoglottis Vieillardii Reichenbach f. in Linnaea, XLI. 85 (1877).

Santa Cruz Group: Vanikoro, common in rain-forest at sea level, no. 563, November 6, 1928 (a ground orchid common throughout the New Hebrides; color of the flowers varies from white to purple; diameter 4 cm.; inside of flower yellow).—Already reported from Tanna.—Also New Caledonia.

Bulbophyllum sp.

Santa Cruz Group: Vanikoro, common in rain forest at 150 m., no. 680, December 3, 1928 (an orchid growing on trees close to the sea; flowers dark red, inconspicuous petals; fruit 5 cm. long, 2.4 cm. in diameter).

This species is in advanced fruit. It is probably referable to *B. praealtum* Kraenzl. from Samoa, but the flowers are too old to be serviceable in attempts at identification. In general habit the plant resembles closely *Macrolepis longiscapa* A. Rich. and may be identical with it. *Macrolepis longiscapa* was originally found on Vanikoro. The genus *Macrolepis* is referable to *Bulbophyllum*, but Richard's species has never been transferred to *Bulbophyllum*. *B. longiscapum* Rolfe from Fiji would appear from the description to belong in the same alliance with Richard's species and with *B. praealtum* Kraenzl. Until a critical study of these species has been made it would be unwise to propose a new name under Bulbophyllum for Richard's *Macrolepis longiscapa*.

Vandopsis Warocqueana (Rolfe) Schlechter in K. Schumann & Lauterbach, Nachtr. Fl. Deutsch. Schutzgeb. 225 (1905).

Santa Cruz Group: Vanikoro, common in rain-forest at 150 m., no. 586, November 8, 1928 (climbing orchid going up trees that are more or less leaning; flower yellowish green with light purple spots).—Also New Guinea.

Vandopsis Quaifei (Rolfe) Schltr. from Espiritu Santo is a closely allied species and may prove to be conspecific with *V. Warocqueana*. In the Kew Herbarium there is a specimen from Aneityum that is surely referable to *V. Warocqueana*, but it is in a fruiting condition and hardly satisfactory for critical study. This specimen was collected by Dr. R. Morrison on June 20, 1896 on the coast east of Anelgauhat.

Saccolabium Kajewskii Ames, sp. nov.

Caules vaginis foliorum obtecti. Folia ligulata, coriacea, utrinque attenuata, apice inaequaliter et obtuse bilobulata, basi in petiolum brevem conduplicatum contracta. Pedunculus elongatus, infra racemum paucibracteatus, bracteis infundibuliformibus. Racemus cylindraceus vel cylindraceo-secundus. Sepala anguste ovata vel elliptica. Petala elliptica, acuta vel subobtusa, trinervia. Labellum longe calcaratum; lamina infra apicem suborbicularis, antice in apicem complanatum contracta.

Stem about 5 cm. or more long, rigid, completely concealed by the sheaths to which the leaves are articulated. Leaves distichous, 14–21 cm. long, up to 2 cm. wide, oblong, ligulate, unequally and bluntly bilobed at the apex. Peduncle with the raceme up to 19 cm. long, with about 3 infundibuliform bracts. Raceme up to 9 cm. long, densely many-flowered. Bracts of the inflorescence scale-like, very much shorter than the pedicels, 1.5 mm. long. Pedicel with the ovary 9 mm. long. Flowers including the spur of the lip 1.3 cm. long. Lateral sepals about 5 mm. long, 2 mm. wide, ovate or elliptical, obtuse, concave. Upper sepal similar. Petals about 5 mm. long, 2 mm. wide, elliptical, acute, 3-nerved. Labellum including the spur 1 cm. long, in front dilated into an orbicular lamina which terminates in a complanate tip; lamina with an intramarginal keel; spur 7 mm. long, inflated below the middle. Column 1.5 mm. long.

Efate: Undine Bay, common in rain-forest along sea shore, no. 205 (type in Herb. Ames no. 36375), April 4, 1928 (color of flowers ranging from creamy white to white with green, some purple, others pink). Banks Group: Vanua Lava, common along sea shore, no. 448, July 9, 1928 (found growing close to the sea on trees whose trunks are well shaded).

Two specimens referable to this species are in the Kew Herbarium. They were collected on Efate, UndineBay, in August 1896 by Dr. R. Morrison. One of these specimens differs from the type in having broader leaves.

Arnold Arboretum,
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A NEW GENUS OF THE ORCHIDACEAE FROM THE NEW HEBRIDES

OAKES AMES

AMONG the orchids collected in the New Hebrides by Dr. R. Morrison in 1896 and by L. Cheeseman in 1930, there is a strikingly distinct species from Eromanga Island. I have been unable to refer it to any genus heretofore described. In general facies it suggests some of the species of the African genus *Acrolophia*, but is clearly differentiated by the very dissimilar means by which the pollen masses are attached to the viscid disc of the rostellum, by the absence of a well developed spur at the base of the labellum and by the aspect of the inflorescence.

For the opportunity of studying the material on which the following description is based I am indebted to the Director of the Royal Botanic Gardens, Kew.

Trichochilus Ames, gen. nov.

Divisio: *Acrotonae;* Tribus: *Kerosphaerinae;* Subtribus: *Polystachyeae.* Sepala lateralia patentia, basi columnae pedi affixa. Sepalum dorsale liberum. Petala sepalis similia. Labellum cum pede columnae inarticulatum, basi contracta incumbens, dein erectum, trilobatum, in saccum vel calcar abbreviatum plus minusve globosum productum, antice in laminam plus minusve pilosam productum, prope basim laminae bicallosum; lobi laterales patentes. Discus labelli conspicue papillosus vel pilosus. Columna elongata, in pedem brevem producta. Anthera terminalis, bilocularis. Pollinia duo, globosa, stipitibus duobus distinctis affixa, glandula unica.—Herba terrestris. Folia equitantia, numerosa. Vernatio foliorum duplicativa. Species una adhuc nota, habitu Acrolophiarum.

Trichochilus neo-ebudicus Ames, sp. nov.

Radices valde incrassatae. Caules abbreviati, basibus foliorum omnino obtecti. Folia plus minusve equitantia, oblique erecta, longe triangularia, acuta, in sicco nervosa. Pedunculus elongatus gracilis, infra racemum paucibracteatus. Racemus laxus, plus minusve decemflorus. Flores membranacei, albidi, labello purpureo-tincto. Sepala lateralia oblongo-lanceolata, patentia. Sepalum dorsale simile. Petala oblongo-lanceolata. Labellum trilobatum, toto disco per medium inaequaliter pilosum et papillosum, basi saccatum vel breviter calcaratum; lobi laterales oblongi,

obtusi; lobus medius anguste ovatus vel obovatus, obtusus, prope basim bicallosus callis papillosis, prope apicem crista pilosa ornatus. Columna elongata, incrassata, in pedem brevem producta. Pollinia duo, globosa.

Roots very stout, when dry about 5 mm. in diameter. Stem much abbreviated, about 1.5 cm. long, concealed by the equitant leaves. Leaves 1.5–4 cm. long, ± 8 mm. wide, duplicative, persistent, narrowly triangular, acute, about 6, ascending with the apices curving inward toward the base of the elongated peduncle, conspicuously many-nerved when dry. Peduncle wand-like, slender, about 2 mm. in diameter when dry, about 5 dm. long, provided with about 5 tubular acute bracts below the raceme. Bracts 1–1.5 cm. long. Raceme about 10-flowered, 4–10.5 cm. long, about 4 cm. in diameter. Flowers about 5 mm. apart, white transfused with mauve. Bracts of the raceme 4–5 mm. long, narrowly lanceolate, acute, spreading, much shorter than the pedicels, brownish when dry. Pedicels about 1 cm. long, very slender, obliquely ascending. Ovary about 3 mm. long, arcuate. Lateral sepals 12–15 mm. long, 2.5 mm. wide, oblong-lanceolate, obtuse or subacute, membranaceous, forming a blunt mentum, 5-nerved with the outer nerves less conspicuous than the three middle ones. Upper sepal similar, about 12 mm. long. Petals about 12 mm. long, 3–3.5 mm. wide, similar to the sepals. Labellum about 11.5 mm. long, conspicuously 3-lobed, sharply deflexed near the base, forming a basal abbreviated sac or spur 1 mm. deep; lateral lobes hardly 3 mm. long, 1 mm. wide, oblong, obtuse, membranaceous, 2–3-nerved, divaricate; middle lobe about 8 mm. long, 3.5 mm. wide at the middle, narrowly ovate, obtuse, pubescent along the middle, contracted at base into an abbreviated oblong claw, bicallose at base with the calli extending down the claw, somewhat thickened at the slightly convex apical portion where it is densely covered with hairs. Calli densely pubescent. Column about 5.5 mm. long, fleshy, dilated upwards, produced at base into a short flat foot and with the base of the adherent labellum forming the short blunt sac. Pollina 2, spherical, waxy, each pollen mass supported by a slender elongated stipe. Stipes of the pollinia widely separated on the orbicular viscid disc.

New Hebrides. Eromanga; Cooks Bay, *Morrison*, s. n., July 22, 1896 (type in Herb. Kew.; duplicate of type in Herb. Ames, no. 37776); tableland, *Morrison*, s. n., July 16 & 22, 1986; Ulaveri plateau, *Morrison*, s. n., July 16, 1896; without exact location, *Morrison*, s. n., July 17, 1896; tableland of volcanic ash, among grass, and also among bracken, and at edge of belts of brush, altitude 500–700 feet, August 4, 1930, *L. Cheeseman*, no. 59.

It is clear that this species belongs to the subtribe Polystachyeae. Vegetatively it resembles *Acrolophia tristis* Schltr. & Bolus and *A. lamellata* Schltr. & Bolus, but is separable from them in the structure of the pollinarium, in the much shorter leaves, and through the absence of a conspicuous spur at the base of the labellum.

In the specimens studied the leaves are closely appressed to the base of the slender peduncle and are nearly parallel with it. Whether or not the leaves elongate as the plant matures is a question that cannot now be answered.

ARNOLD ARBORETUM,
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SYNOPSIS OF THE CHINESE SPECIES OF JASMINUM

CLARENCE E. KOBUSKI

JASMINUM is essentially a tropical or subtropical genus and is found in eastern and southern Asia, Malaysia, Africa, Australia and even tropical America. There are probably over three hundred species recognized in the genus at the present time. In the herbarium of the Arnold Arboretum are represented species from all these regions. However, the region best represented is China. Of the few species not found in this herbarium, photographs of the type specimens were taken by Alfred Rehder on a recent visit to European botanical institutions from which he brought back over 500 photographs of types of Chinese ligneous plants. This gave us a nearly complete representation of the Chinese species of *Jasminum* and made possible the present study.

Since the time of Linnaeus there has been made only one attempt toward a complete representation of the genus; this was published in 1844 by A. P. De Candolle (Prodr. VIII. 300–316). Of the Chinese species three enumerations were published, namely by Hemsley, Léveillé and Chung.

W. B. Hemsley (Enumeration of all the Plants known from China proper, Formosa, Hainan, the Corea, the Luchu Archipelago and the Island of Hongkong) in Jour. Linn. Soc. XXVI. 78–82 (1889) recognized fifteen species. H. Léveillé in handling his "Jasmina Sinensia" in Fedde, Rep. Nov. Spec. XIII. 149–150 (1914) mentions thirty-three species in his key while H. H. Chung publishing a "Catalogue of Trees and Shrubs of China" in Mem. Sci. Soc. China, I. no. 1 (1924) lists 27 species and two varieties.

As already mentioned in this paper there are over three hundred species. Early in the study we thought that most of these species were distributed in southeastern Asia and Malaysia and that here probably was the main center of distribution of the genus. However, in careful listing of all species of the genus as recognized by "Index Kewensis" we discovered that while there were approximately one hundred species of *Jasminum* found in China (especially south-west) and the Himalayan region of India there were about the same number of species found in Malaysia and about one hundred twenty species in Africa. Besides these numbers there is a sprinkling of a few species in Australia, Polynesia and tropical America. All together this makes the genus pan-tropical with a possible center of distribution found in the area including Malaysia, the Himalayas and China.

These numbers have been taken from species recognized by the Index Kewensis. Incidentally, of the fifty-six species belonging within the scope of this study approximately one-half turned out to be synonyms. No new species was found among the unidentified material either at the Arnold Arboretum or the material borrowed from other institutions. This may intimate that since *Jasminum* is composed mostly of such interesting and decoratively beautiful shrubs that the majority of species were found early by plant collectors and described at that time. It is evident that later botanists encountering some of these already described new species for the first time, lacking both material with which to compare them and literature, also have described several of the outstandingly distinct species a second and even a third time. At present, when the material (types or photographs of types) was brought together for the first time it was positively amazing to find the species duplications which had taken place.

One cannot be positive but it seems quite logical to assume that the same situation may be found in a study of *Jasminum* from any other distinct locality. This would decrease the number of recognized species considerably.

The genus is botanically separated quite easily into four distinct sections; the sections being based on leaf characters. These sections were all introduced by DeCandolle in his Prodromus. The Alternifolia group with alternately arranged leaves is perhaps the most outstandingly different. It contains five species and varieties. The opposite-leaved sections are three, namely: Unifoliolata (13 species); Trifoliolata (9 species and varieties); Pinnatifolia (5 species and varieties). The delimiting characters of these groups can easily be ascertained from their significant names.

In addition to the material in the herbarium of the Arnold Arboretum, photographs of types were secured and loans of material obtained from the herbaria of the New York Botanic Garden, the Philippine Bureau of Science, Gray Herbarium of Harvard University, Royal Botanic Garden at Edinburgh, British Museum of Natural History and Royal Botanic Gardens at Kew. Opportunity is taken at this time by the author to express his gratitude to all members of these institutions mentioned above who aided in photographic work or selection of the specimens loaned. Especial thanks are due Mr. Alfred Rehder, Curator of the Herbarium, for the suggestion of the problem and for the ever kind and helpful interest which has been shown me at all times during the progress of this work.

The abbreviations of the herbaria used in this paper are as follows:

(AA) = Arnold Arboretum of Harvard University
(B) = British Museum of Natural History
(Br) = University of Breslau
(C) = University of California
(E) = Edinburgh, Royal Botanic Garden
(G) = Gray Herbarium of Harvard University
(K) = Kew, Royal Botanic Gardens
(NY) = New York Botanical Garden
(P) = Philippine Bureau of Science

KEY TO THE SERIES

A. Leaves alternately arranged ..... 1. ALTERNIFOLIA
AA. Leaves opposite in arrangement.
B. Leaves compound.
C. Leaves trifoliolate ..... 2. TRIFOLIOLATA
CC. Leaves five-foliolate or more ..... 3. PINNATIFOLIA
BB. Leaves simple ..... 4. UNIFOLIOLATA

Series 1. ALTERNIFOLIA DC.

A. Calyx teeth subulate-setaceous, longer than calyx-tube.
B. Leaves and plant glabrous ..... 1. *J. floridum*
BB. Leaves puberulous ..... 2. *J. Giraldii*
AA. Calyx lobes shorter than calyx-tubes, diminutive or obtuse.
B. Leaves both simple and ternate; leaflets 5–8 cm. long; inflorescence 30–50-flowered, corymbs 7–12 cm. across.
C. Calyx lobes and pedicels glabrous.
3a. *J. heterophyllum* var. *glabricorymbosum*
CC. Calyx lobes and pedicels villous.
3b. *J. heterophyllum* var. *subhumile*
BB. Leaves only ternate or pinnate; leaflets 1.5–3.5 cm. long; inflorescence 3–8 flowered ..... 4. *J. humile*

1. **Jasminum floridum** Bunge in Mém. Div. Sav. Acad. Sci. St. Pétersb. II. 116 (Enum. Pl. China Bor. 42) (1833).—DeCandolle, Prodr. VIII. 313 (1844).—Nicholson, Ill. Dict. Gard. II. 207 (1877).—Miquel in Ann. Mus. Ludg.-Bat. II. 263 (1866); Prol. Fl. Jap. 151, 359 (1866–67).—Franchet & Savatier, Enum. Pl. Jap. I. 314 (1875).—Hooker f. in Bot. Mag. CIX. t. 6719 (1883).—Hemsley in Jour. Linn. Soc. XXVI. 78 (1889).—Diels in Bot. Jahrb. XXIX. 534 (1900).—Schneider, Ill. Handb. Laubholzk. II. 839, figs. 527h-i, 528a (1911).—Léveillé in Fedde, Rep. Spec. Nov. XIII. 149 (1914).—Rehder in Sargent, Pl. Wilson. II. 614 (1916); Man. Cult. Trees Shrubs, 765 (1927).—Chung in Mem. Sci. Soc. China, I. no. 1, 216 (1924).

Jasminum subulatum Lindley in Bot. Reg. XVIII. misc. notes, 57 (1842).—DeCandolle, Prodr. VIII. 312 (1844).

Jasminum floridum Bunge var. *spinescens* Diels in Bot. Jahrb. XXIX. 534 (1901).—**Syn. nov.**

Jasminum Argyi Léveillé in Mem. Acad. Ci. Art. Barcelona, XII. no. 22, 17 (1916).—**Syn. nov.**

Chihli: Peking, *C. A. Skatchkov* (1848–1857) (G). Kiangsu: Le kien, *Ch. d'Argy*, May (1846–66) (AA, type of *J. Argyi*); Nanking, *L. F. Tsu*, no. 629, May 19, 1921 (C). Western Hupeh: north and south of Ichang, alt. 300–700 m., *E. H. Wilson*, no. 789 in part, June and December 1907 (bush 1 m. tall; flowers yellow; fruit black) (AA, G); open, grassy slopes, Ichang, *W. Y. Chun*, no. 3468, July 20, 1922 (bush 1 m. high; flowers yellow) (AA); thickets, Hsing-shan hsien, alt. 600 m., *E. H. Wilson*, no. 789 in part, June 1907 (AA); moist shady cliff, Gian Gia-kou, *W. Y. Chun* (*Huang Tsung*), no. 3572, July 27, 1922 (shrub 1–2 m.; leaves dull green above; flowers yellow) (AA); without precise locality, *E. H. Wilson* (Veitch Exped. no. 83) April 1900 (AA, NY); without precise locality, *A. Henry*, nos. 2700 (NY, G) and 6288 (AA, NY). Kansu: near Kua tsa, *F. N. Meyer*, no. 1817, Nov. 5, 1914 (C). Western Szechuan: Nanch'uan, Fu pei tsui, *C. Bock* and *A. von Rosthorn*, no. 1151, Oct. 1891 (photo. and fragment of holotype of *J. floridum* var. *spinescens*) (AA); Nanch'uan, Taho-kou, *C. Bock* and *A. von Rosthorn*, no. 163, July 1891 (AA); side of river, Nanchuan hsien, alt. 1525–1830 m., *W. P. Fang*, no. 788, May 15, 1928 (shrub 1 m.; flowers yellow) (AA, NY); side of brook, Sungpan hsien, *W. P. Fang*, no. 4239, August 17, 1928 (shrub 2–3 m.; flowers yellow) (AA, NY).

In comparing *J. Argyi* Léveillé with material of *J. floridum* Bunge, no differences warranting specific delimitation could be found, nor does *J. floridum* var. *spinescens* Diels seem to be different enough from typical *J. floridum* to be maintained as a distinct variety.

2. **Jasminum Giraldii** Diels in Bot. Jahrb. XXIX. 534 (1901).—Pampanini in Nuov. Giorn. Bot. Ital. n. ser. XVII. 689 (1910).—Léveillé in Fedde, Rep. Spec. Nov. XIII. 149 (1914).—Bailey, Standard Cycl. Hort. 1719 (1915).—Rehder in Sargent, Pl. Wilson. II. 614 (1916); Man. Cult. Trees Shrubs, 765 (1927).—Chung in Mem. Sci. Soc. China, I. no. 1, 216 (1924).

Jasminum tsinlingense Lingelsheim in Fedde, Rep. Spec. Nov. Beih. XII. 463 (1922).—**Syn. nov.**

Shensi: King lung shan, alt. 900 m., *J. Hers*, no. 2440, Oct. 9, 1922 (AA); In kia p'u, *G. Giraldi*, no. 1518, August 1897 (fragment of syntype from Herb. Mus. Berlin) (AA); Huo kia zaez, at foot of Lao y huo, *G. Giraldi*, no. 1519 (photograph of syntype in Herb. Mus. Berlin) (AA); same locality, June 4, 1897, *G. Giraldi* (AA); northwest of Hangcheng hsien, *W. Purdom*, no. 368, date lacking (1 m. high; flowers yellow) (AA); Tai-pei-shan, *W. Purdom*, nos. 907 and 908, in 1910 (AA); at foot of mts. at Schian gou, south Hsian fu, Tsin ling schan, alt. 500 m., *W. Limpricht*, no.

2689 (photograph and fragment of type of *J. tsinglingense* from Br. in AA). Hupeh: dry rocky places, Fang hsien, alt. 1000 m., *E. H. Wilson*, no. 598, May 23, and Nov. 1907 (abundant; 1–2 m.; flowers deep yellow; fruit black) (AA, G, NY, C).

Lingelsheim's species *Jasminum tsinglingense* is undoubtedly synonymous with *J. Giraldii* Diels.

3a. **Jasminum heterophyllum** Roxb. var. **glabricorymbosum** W. W. Smith in Notes Roy. Bot. Gard. Edinburgh, XII. 209 (1920).

Yunnan: on ledges of limestone cliffs, on Langhong—Hoching divide, lat. 26° 16′ N., alt. 2440 m., *G. Forrest*, no. 9990, May 1913 (shrub 2–3 m.; flowers deep golden yellow, fragrant) (AA); in open situations by streams, Yungpe mountains, lat. 26° 45′ N., alt. 2740 m., *G. Forrest*, nos. 11037 (NY), 11177 (C), and 11472, Sept.–Oct. 1913 (erect shrub 2–2.5 m.; fruit black) (AA); Mengtze woods, alt. 1475–1525 m., *A. Henry*, nos. 9107, 9107A and 9107B (slender shrubs 2–2.5 m.; flowers yellow; fruit black) (AA, NY); forests, Ta Song pin, *Simeon Tén*, no. 99, March 26, 1916 (tree 3 m.; flowers yellow) (AA); eastern slopes of Likiang Snow Range, Yangtze watershed, Prefectural District of Likiang, *J. F. Rock*, nos. 3879, 3955, May–Oct. 1922 (shrub 2–2.5 m.; flowers orange-yellow) (AA, NY); mountains south of Likiang Sungkwe Hochin Range, *J. F. Rock*, no. 8292 in 1923 (shrub 1.5–2 m.; flowers yellow) (AA); western slope of Likiang Snow Range, Yangtze watershed, *J. F. Rock*, no. 8539 April 1923 (shrub 3 m.; drooping yellow flowers) (AA); banks of Djiper Ka Ku stream, near Ngaza, drainage basin of the Yangtze, west of Likiang, *J. F. Rock*, no. 10602, in 1923 (shrub 1 m.) (AA); Shweli River drainage basin and environs of Tengyueh, *J. F. Rock*, no. 8033, February 1923 (shrub 1.2–2 m.; flowers citron-yellow) (AA); headwaters of the Red River or Menghuaho from Maokai to Tatsang, alt. 1675 m. *J. F. Rock*, no. 3026, April 8, 1922 (flowers yellow) (AA).

3b. **Jasminum heterophyllum** Roxb. var. **subhumile** (W. W. Smith), comb. nov.

Jasminum subhumile W. W. Smith in Notes Bot. Gard. Edinb. VIII. 127 (1913).

Yunnan: moist open situation in the Sha-Yang valley, lat. 25° 20′ N., alt. 1830 m., *G. Forrest*, no. 5529, April 1910 (flowers orange-yellow, fragrant) (E, type of *J. subhumile*); open situation in the Pu-piao valley, lat. 25° ′5 N., alt. 1830–2135 m., *G. Forrest*, no. 9873, May 1913 (shrub 1.5–3 m.; flowers deep golden yellow, fragrant) (AA, C).

This variation of *J. heterophyllum* was originally described as *J. subhumile*. However, it differs from *J. heterophyllum* only in

its densely villous pubescence found on the calyx and pedicels. The pubescence on *J. heterophyllum* is of a puberulent nature. It is interesting to find these two extreme variations, namely the present villous variety along with the glabrous variety mentioned before both growing in China, while the typical species has been found only in the Himalayan region.

4. Jasminum humile Linnaeus, Spec. Pl. I. 7 (1753).—Aiton, Hort. Kew. I. 9 (1789).—Ker in Bot. Reg. V. t. 350 (1819).—St. Hilaire, Pl. France, II. t. 110 (1808); Traité Arbriss. & Arbustes, II. t. 90 (1825).—DeCandolle, Prodr. VIII. 313 (1844).—Clarke in Hooker f., Fl. Brit. Ind. III. 602 (1822).—Nicholson, Illustr. Dict. Gard. II. 207 (1887).—Dippel, Handb. Laubholzk. I. 146, fig. 91 (1889).—Bailey, Cyclop. Amer. Hort. II. 843, fig. 1191 (1900); Stand. Cyclop. Hort. III. 1719, fig. 209 (1915).—Léveillé in Fedde, Rep. Spec. Nov. XIII. 149 (1914).—Brandis, Ind. Trees, 452 (1906).—Schneider, Ill. Handb. Laubholzk. II. 840 (1911).—Rehder in Sargent, Pl. Wilson. II. 615 (1916); Man. Cult. Trees Shrubs, 765 (1927).—Chung in Mem. Sci. Soc. China, I. no. 1, 216 (1924).—Boynton in Addisonia, XII. 55, pl. 412 (1927).

Jasminum chrysanthemum Roxburgh, Cat. Hort. Beng. 3 (1814), nomen; Fl. Ind. I. 98 (1820).

Jasminum revolutum Sims in Bot. Mag. XLII. t. 1731 (1815).—Ker in Bot. Reg. III. t. 178 (1817); VI. notes 2 (1820).—Loddiges in Bot. Cab. X. t. 966 (1824).—D. Don, Prodr. Fl. Nepal. 106 (1825).—De Candolle, Prodr. VIII. 313 (1844).—Wight, Icon. Pl. Ind. Orient. IV. 14, t. 1258 (1850).—Brandis, Forest Fl. Brit. Ind. 313 (1874).—Boissier, Fl. Orient. IV. 42 (1879).—Dippel, Handb. Laubholzk. I. 148, fig. 93 (1889).—Schneider, Ill. Handb. Laubholzk. II. 839, figs. 527 m-n, 528 g-i (1911).

Jasminum bignoniaceum Wallich, Cat. No. 2888 (1829), nomen nudum.—G. Don, Gen. Syst. IV. 63 (1838).—DeCandolle, Prodr. VIII. 313 (1844).

Jasminum Wallichianum Lindley in Bot. Reg. XVII. t. 1409 (1831).—Schneider, Ill. Handb. Laubholzk. II. 839, figs. 527 k-l, 528 d-f (1911).

Jasminum inodorum Jaquemont apud Decaisne in Jacquemont, Voy. IV. 139. t. 143 (1844).—DeCandolle, Prodr. VIII. 312 (1844).

Jasminum Mairei, Léveillé in Fedde, Rep. Spec. Nov. XIII. 337 (1914).—**Syn. nov.**

Jasminum Mairei Léveillé var. *siderophyllum* Léveillé, Cat. Pl. Yun-nan, 179 (1916).—**Syn. nov.**

Kansu: Lower Tebbu country: slopes along gorge of Chulungapu, alt. 1980 m., *J. F. Rock*, no. 15035, Sept.-Oct. 1926 (shrub 1–1.7 m.; flowers yellow; fruit black) (AA); dry arid slopes with Oaks in Nyibaku, alt. 1900 m., *J. F. Rock*, no. 14797, Sept. 9, 1926 (shrub 1–1.5 m.; flowers rich yellow) (AA); outskirts of forests along stream in Wantsang valley, alt. 2135–2200 m., *J. F. Rock*, no. 14653, Aug. 31, 1926 (shrub 1–1.5 m.) (AA). Western Szechuan: descent of Hsao-chin-lo, Monkong Ting,

alt. 2300–3000 m., *E. H. Wilson*, no. 2809, June 1908 (bush 1–2 m. tall; flowers yellow) (AA); dry arid places, Maochou, alt. 1300–1600 m., *E. H. Wilson*, no. 2811, May 24, 1908 (bush 0.3–2 m. tall; flowers yellow) (AA); in dumetis mont., inter Kalapo et Linku, alt. 3000 m., *C. K. Schneider*, no. 1302, May 17, 1914 (AA); inter Huale et Mo lien, alt. 2600 m., *C. K. Schneider*, no. 4091, May 25, 1914 (AA); Teng-hsiang-ying, alt. 2100 m., *Harry Smith*, no. 1890, May 20, 1922 (in prato fruticoso-herboso) (AA); inter Wen-ch'uan-hsien et Hsin-p'u-kuan, alt. 1300 m., *Harry Smith*, no. 2463, June 28, 1922 (flor. sulphurei) (AA); without exact locality, alt. 3000–3300 m., *E. H. Wilson* (Veitch Exped. no. 4077) June 1904; alt. 2300 m., *E. H. Wilson* (Veitch Exped. no. 4078) August 1903 (AA). Yunnan: high plateau between Talifu and Likiang to the foot of the Likiang Snow Range, *J. F. Rock*, no. 3293, May 6–11, 1922 (shrub; flowers yellow) (AA); about Pe Yen tsin, *Simeon Tén*, no. 515, June 18, 1918 (shrub 1–2 m.) (AA); Pin tchoan kai, about Pe Yen tsin, *Simeon Tén*, no. 375, May 15, 1917 (spreading shrub 1–2 m.; flowers yellow) (AA); open situation on arid foothills of eastern flank of Bei-ma Shan, lat. 28° 12′ N., alt. 3050 m., *G. Forrest*, no. 13832, June 1917 (shrub 1–2 m.; flowers deep golden yellow) (AA); vallons de Suen-oui, alt. 2400 m., *E. E. Maire* (AA, no. 451), July (arbrisseau buissonnant; fleurs jaunes) (AA); vallée de Gui-ma-tong, alt. 2500 m., *E. E. Maire* (AA, no. 245) May (arbuste buissonnant non grimpant; fleurs jaunes) (AA); open situation in mixed and pine forests on the eastern flank of the Tali Range, lat. 25° 40′ N., alt. 2440–3050 m., *G. Forrest*, no. 4659, June–August 1906 (shrub 1–2 m., flowers orange-yellow, fragrant) (AA); in calcareous mountains, region of Yunnan fu, alt. 2200 m., *O. Schoch*, no. 36 (AA); in hedges near Hoching, alt. 2500 m., *C. K. Schneider*, no. 3264, Sept. 26, 1914 (AA); in thickets near streams at foot of mountain near Lichiang, alt. 3000 m., *C. K. Schneider*, no. 3222, Oct. 6, 1914 (AA); haut plateau de Tai hai, alt. 3200 m., *E. E. Maire*, July (1911–13) (arbuste buissonnant; haut 0.60 m.; fleurs roses) (AA); patûrages des montagnes à Pe-ling-tsin, alt. 3200 m., *E. E. Maire*, May (1911–13) (buissonnant, haut 0.60 m.; fleurs jaunes, inodores) (AA). Southeast Tibet: open scrub by streams on the Salween-Kiu-chiang divide, Tsarong, lat. 28° 40′ N., long. 98° 15′ E., alt. 2135–2440 m., *G. Forrest*, no. 18927, September 1919 (shrub 1–2 m.) (AA); amongst rocks on dry stony slopes in side valleys on the Salween-Kiu-chiang divide, Tsarong, lat. 28° 40′ N., long. 98° 15′ E., alt. 2440 m., *G. Forrest*, no. 19251, September 1919 (shrub 0.5 m.) (AA).

In examining the Indian along with the Chinese material, one, at first, is impressed with the seeming differences and inclined to recognize the species *J. revolutum* Sims and *J. Wallichianum* Lindley as distinct from *J. humile* L. This separation would be based on the larger, more numerous and rather obtuse leaflets of the Indian material as compared with the small, acute, and lesser numbered leaflets of the Chinese species. The number of flowers in the inflorescence of the Himalayan material is greater (usually 8–10) as contrasted with the usual 3–5-flowered inflorescence of the Chinese specimens. On careful study of the massed material, however, one finds a sufficiently distinct graduation or variation in all the characters mentioned making it difficult to recognize anything other than a single, very variable species, *J. humile*.

Series 2. TRIFOLIOLATA DC.

A. Calyx lobes foliaceous.
B. Leaves persistent, coriaceous, present at time of flowering ..... 5. *J. Mesnyi*
BB. Leaves deciduous; flowers appearing before leaves.
C. Plants erect or scandent; simply branched.
D. Leaves uniformly green ..... 6. *J. nudiflorum*
DD. Leaves variegated or entirely yellow .. 6a. *J. nudiflorum* f. *aureum*
CC. Plants pulvinate; intricately ramose. ..... 6b. *J. nudiflorum* var. *pulvinatum*
AA. Calyx lobes quite vestigial or subulate when present.
B. Leaves palmately tri-nerved.
C. Branchlets and leaves glabrous ..... 7. *J. urophyllum*
CC. Branchlets and leaves puberulent .. 7a. *J. urophyllum* var. *Wilsonii*
BB. Leaves pinnately veined.
C. Leaves and branches glabrous ..... 8. *J. lanceolarium*
CC. Leaves and branches pubescent.
D. Calyx lobes quite vestigial; terminal leaflets same size or only slightly larger than lateral leaflets ..... 8a. *J. lanceolarium* var. *puberulum*
DD. Calyx lobes subulate-setaceous; terminal leaflets markedly longer than lateral leaflets ..... 9. *J. sinense*

5. **Jasminum Mesnyi** Hance in Jour. Bot. XX. 37 (1882).—Hemsley in Jour. Linn. Soc. London, XXVI. 79 (1889).—Léveillé in Fedde, Rep. Spec. Nov. XIII. 150 (1914).—Chung in Mem. Sci. Soc. China, I. 216 (1924).

Jasminum primulinum Hemsley apud Baker in Kew Bull. Misc. Inform. 1895, p. 109; apud Oliver in Hooker, Ic. Pl. XXIV. t. 2384 (1895).—Léveillé in Fedde, Rep. Spec. Nov. XIII. 150 (1914).—Bailey, Stand. Cyclop. Hort. III. 1718 (1915).— Chung in Mem. Sci. Soc. China, I. 216 (1924).—Rehder, Man. Cult. Trees Shrubs, 764 (1927).—**Syn. nov.**

Yunnan: between Szemao and Nakoli, *J. F. Rock*, no. 2829, March 13, 1922 (shrub with straggling branches; flowers yellow) (AA); mountains near Szemao, alt. 1525 m., *A. Henry*, no. 9319A (straggly shrub with yellow flowers) (AA, C); brousse de montagne à Siao-long-tan, alt. 2600 m., *E. E. Maire*, AA, no. 199, April?

(arbuste en touffes, long rameaux verts; fleurs jaunes, simples ou doubles) (AA); dumetis ad vicum Dschung-duilung, prope urbem Yunnanfu, alt. 2000 m., *H. Handel-Mazzetti*, no. 8613, February 7, 1916 (flores flavi) (AA); an Bahn bei Yi leang hien, *C. K. Schneider*, no. 32, Feb. 5, 1914 (AA); westlich von der Yangtze Fähre, La ka tiang, *C. K. Schneider*, no. 486, March 19, 1914 (niederliegender sparriger Strauch) (AA); Mengtze, alt. 1370–1525 m., *A. Henry*, no. 9319 (shrub 1 m., flowers yellow) (AA, NY); amongst scrub, hills to the south of Tengyueh, lat. 25° N., alt. 1830 m., *G. Forrest*, no. 9744, March 1913 (shrub 1.5 m.; flowers bright golden yellow) (AA); dry rocky situation on the Langkong-Hoching divide, lat. 26° 16′ N., alt. 2440–2740 m., *G. Forrest*, no. 9955, May 1913 (shrub 0.5–1.0 m., flowers golden yellow) (AA); Yunnan fu, in fruticetis, alt. 1900 m., *Harry Smith*, no. 1583, August 4, 1922 (AA); precise locality and date lacking, *F. Ducloux*, nos. 165, 7175 (NY). Kweichou: prope Mei-chu-chin, alt. 1830 m., *W. Mesny* (Hance herb. no. 21211), April 11, 1880, (B, type), photo. of type (AA).

Unfortunately in describing *J. primulinum*, Hemsley (1895) was not aware of *J. Mesnyi* described by Hance in 1882. Since Hemsley's time this species has been known generally as *J. primulinum* instead of the earlier name *J. Mesnyi*.

J. Mesnyi seems to be the southern counterpart of *J. nudiflorum*. It is difficult to find sound morphological characters for specific delimitation. *J. nudiflorum* is confined (spontaneously) to N. China and is characterized by deciduous leaves and precocious flowers with the corolla tube longer than the spread of its lobes. *J. Mesnyi*, on the other hand, is usually found in Yunnan and differs from *J. nudiflorum* in having evergreen leaves and larger, usually double flowers with the corolla-lobe spread greater than the length of the tube.

6. **Jasminum nudiflorum** Lindley in Jour. Roy. Hort. Soc. London, I. 153 (1846); Bot. Reg. XXXII. t. 48 (1846); Bot. Mag. LXXVIII. t. 4649 (1852).—Walpers, Repert. Bot. Syst. VI. 463 (1846–47).—Franchet, Pl. David. I. 206 (1884).—Hemsley in Jour. Linn. Soc. London, XXVI. 79 (1889).—Schneider, Ill. Handb. Laubholzk. II. 837 (1912).—Léveillé in Fedde, Rep. Spec. Nov. XIII. 150 (1914).—Bailey, Stand. Cyclop. Hort. III. 1718 (1915).—Chung in Mem. Sci. Soc. China, I. 216 (1924).—Rehder, Man. Cult. Trees Shrubs, 764 (1927).

Jasminum angulare Bunge in Mém. Div. Sav. Acad. Sci. St. Pétersb. II. 116 (Enum. Pl. China Bor. 42) (1833).—Non Vahl.

Jasminum Sieboldianum Blume, Mus. Bot. Ludg.-Bat. I. 280 (1850).

S h a n s i : Yun-cheng, Chung-t'iao-shan, in prato aprico, *Harry Smith* (*Ssii Ho*), no. 5508, July 1924 (AA). S h a n t u n g : Tsingtao, *R. Zimmermann*, no. 296 in 1901 (AA); along sandy slope under partial shade, Tsingtao, alt. 100 m., *C. Y. Chiao*, no. 2583, June 19, 1930 (bushy vine, ornamental for stone walls) (AA).

6a. **Jasminum nudiflorum** Lindley f. **aureum** Dippel, Handb. Laubholzk. I. 145 (1889), as var.—Schneider, Ill. Handb. Laubholzk. II. 837 (1912), as var.

J. nudiflorum Lindley var. *variegatum* Mouillefert, Arbres Arbriss. II. 1008 (1897).

Hort. L. Spaeth, Baumschulen, Berlin, Aug. 8, 1926 (leaves yellow, green and variegated); same location, *H. Jensen*, in flower, March 21 (1927).

6b. **Jasminum nudiflorum** Lindley var. **pulvinatum** (W. W. Smith), comb. nov.

Jasminum pulvinatum W. W. Smith in Notes Roy. Bot. Gard. Edinb. XII. 209 (1920).

S . E . T i b e t : in open dry situations on cliffs, prov. of Tsarong, on Doker-la, Mekong-Salween divide, lat. 28° 20′ N., alt. 2740–3050 m., *G. Forrest*, no. 14478, July 1917 (cushion shrub of 0.25–0.5 m.; flowers golden yellow) (AA). N . W . Y u n n a n : mountains of Londjre, Mekong-Salween watershed adjoining southeastern Tibet, *J. F. Rock*, no. 8896, May 1923 (shrub 0.25–0.5 m. often prostrate; flowers large rich yellow) (AA, NY); on open moorland, eastern flank of the Bei-ma Shan, lat. 28° 12′ N., alt. 4250–4500 m., *G. Forrest*, no. 13834, July 1917 (stunted, almost spinous shrub, 0.25 m.; flowers bright yellow) (AA); dry situations in ravines in the Salween valley, lat. 28° 10′ N., alt. 2440 m., *G. Forrest*, no. 16193, April 1917 (shrub 0.75–1.5 m.; flowers precocious, bright yellow) (AA); stony pasture and on cliffs on the Bei-ma Shan, lat. 28° 18′ N., long. 99° 10′ E., alt. 3650–3950 m., *G. Forrest*, no. 19666, July 1921 (matted cushion shrub of 0.3–0.75 m; flowers yellow) (AA); on ledges of dry cliffs and rocky slopes in the Atuntze valley, lat. 28° 32′ N., long. 98° 48′ E., alt. 2740–3050 m., *G. Forrest*, no. 20004, August 1921 (stunted shrub 0.3–0.75 m. forming cushions; flowers bright yellow) (AA).

This stunted variety of *J. nudiflorum* Lindl. found growing, as far as is known at present, only in the mountainous regions of N. W. Yunnan and adjacent S. E. Tibet varies from the species *J. nudiflorum* in the cushion like habit and densely intricate branching. It is solely an alpine equivalent of *J. nudiflorum* and not worthy of specific rank.

7. **Jasminum urophyllum** Hemsley in Jour. Linn. Soc. Bot. XXVI. 81 (1889).—Léveillé in Fedde, Rep. Spec. Nov. XIII. 150 (1914).—

Rehder in Sargent, Pl. Wilson. II. 613 (1916).—Chung in Mem. Sci. Soc. China, I. 217 (1924).

Szechuan: Mt. Omei, alt. 1525 m., *Ernst Faber*, no. 47 (flowers yellow) (NY, isotype); in thickets, Kuan hsien, alt. 900–1080 m., *W. P. Fang*, no. 2196, July 14, 1928 (woody vine; flowers white) (AA, NY); in thickets near Mt. Wa, alt. 900 m., *E. H. Wilson*, no. 1122, Oct. 1908 (climber, 2 m.; flowers white) (AA).

An annotation found on the sheet of the type specimen of this species refers to the flowers as yellow. In view of the facts that all other specimens of this species and its variety possess white flowers and that the plant at time of collection from which the type specimen was gathered was evidently nearly past the flowering condition, I feel that, probably, the original specimen possessed white flowers which, because of their aged condition, were termed yellow.

J. urophyllum is closely allied to the Indian *J. dispermum* Wall. in its white flowers, ternately-veined leaflets and calyx characters. However, the two lateral veins in *J. urophyllum* pass well beyond the center toward the apex of the leaf before anastomosing with the small veinlets from the midrib while in the case of *J. dispermum* the veins anastomose well below the center of the leaf. Also the leaves of *J. dispermum* are more vigorous, 5-foliolate and coarser in texture while those of *J. urophyllum* are narrowed and more attenuated, 3-foliolate and finer in texture.

7a. **Jasminum urophyllum** Hemsley var. **Wilsonii** Rehder in Sargent, Pl. Wilson. II. 613 (1916).—Chung in Mem. Sci. Soc. China, I. 217 (1924).

Jasminum urophyllum Hemsley var. *Henryi* Rehder in Sargent, Pl. Wilson. II. 613 (1916).—Chung in Mem. Sci. Soc. China, I. 217 (1924).—**Syn. nov.**

W. Szechuan: cliffs, *E. H. Wilson*, Veitch Exp. no. 4075, July 1903 (shrub 0.6 m. high; flowers white) (AA, type). W. Hupeh: Mt. Changyang, *E. H. Wilson*, Veitch Exp. no. 1499, July 1900 (climber with white flowers) (AA, NY; paratype of var. *Henryi*); Yunnan: on and amongst scrub, divide between the Shweli and Tengyueh valleys, lat. 25° N., alt. 2135 m., *G. Forrest*, no. 8136, June 1912 (scandent shrub 1.5–4.5 m.; flowers, interior ivory-white, exterior flushed rose-crimson, fragrant) (AA).

This variety of *J. urophyllum* is quite distinct and easily recognized from the typical species because of the absence of the pubescent character so prominent in *J. urophyllum*. The variety *J. urophyllum* var. *Henryi* cannot be clearly distinguished from var. *Wilsonii* and was evidently described from rather sparse material.

8. **Jasminum lanceolarium** Roxburgh, Fl. Ind. I. 97 (1820).—DeCandolle, Prodr. VIII. 310 (1844).—C. B. Clarke in Hooker f., Fl. Brit. Ind. III. 601 (1882).—Hemsley in Jour. Linn. Soc. XXVI. 78 (1889).—Léveillé in Fedde, Rep. Spec. Nov. XIII. 150 (1914).—Rehder in Sargent, Pl. Wilson. II. 612 (1914).—Chung in Mem. Sci. Soc. China, I. 216 (1924).

Jasminum paniculatum Roxburgh, Fl. Ind. I. 97 (1820).—Ker in Bot. Reg. IX. t. 690 (1823).—DeCandolle, Prodr. VIII. 310 (1844).—Bentham in Fl. Hongkong, 216 (1861).—Hemsley in Jour. Linn. Soc. XXVI. 80 (1890).—Léveillé in Fedde, Rep. Spec. Nov. XIII. 150 (1914).—Chung in Mem. Sci. Soc. China, I. 216 (1924).—**Syn. nov.**

Jasminum discolor Franchet in Nouv. Arch. Mus. Paris, sér. 2, X. 59 (1888).—Léveillé in Fedde, Rep. Spec. Nov. XIII. 150 (1914).—Chung in Mem. Sci. Soc. China, I. 216 (1924).—**Syn. nov.**

Jasminum pachyphyllum Hemsley in Jour. Linn. Soc. XXVI. 79 (1890).—Léveillé in Fedde, Rep. Spec. Nov. XIII. 150 (1914).—Chung in Mem. Sci. Soc. China, I. 216 (1924).—**Syn. nov.**

Anhwei: in open thickets, E. Wu Yuan, alt. 540 m., *R. C. Ching*, no. 3312, September 4, 1925 (strong, tough climber, 15 m.; bark dark gray, green above, fruit greenish, rounded) (AA). Kiangsi: shady valley near stream, Ting-Nan hsien, alt. 690 m., *H. H. Hu*, no. 1065, June 5, 1921 (vine with white flowers) (AA). Kwantung: Lantau Island (native collector ex *C. Ford*) May 11, 1888 (AA, photo. of type of *J. pachyphyllum*); Hongkong, *C. Ford*, Nov. 22, 1893 (AA); precise locality lacking, *C. Ford*, August 9, 1895 (NY); Hongkong, *C. Wright*, in 1853–1856 (NY); Teng Woo Mt., *C. O. Levine and G. W. Groff*, no. 163, Nov. 18, 1916 (C); same locality, *C. O. Levine*, no. 3107, Sept. 22, 1918 (AA); Loh Fan Mountain, *E. D. Merrill*, no. 10693, August 9–27, 1917 (C, NY); Wong Nei Chong, Hongkong, *Y. Tsiang*, no. 3005, August 1929 (NY); Wukantin, Hongkong, New Territory, *Y. Tsiang*, no. 2970, August 1929 (NY); Tai-O, *Y. K. Wang*, no. 3206, August 1929 (NY); Tai-P, Hongkong, New Territory, *Y. K. Wang*, no. 3219, August (1929) (NY); open scrub, Tai-O, *W. Y. Chun*, no. 3088, August 17, 1929 (scandent shrub; leaves lustrous green; flowers yellow?) (NY); dense woods in partial shade, Sha-ting, Hongkong, *W. Y. Chun*, no. 6911, December 3, 1928 (scandent) (NY); dense woods, side of trail, Forestry Road above Bowen Road, Hongkong, *W. Y. Chun*, no. 7470, September 11, 1929 (scandent shrub; branches purple; leaves deep, dull green above, pale yellow green beneath; flowers white) (NY); Lan Tau Island, *Tsang Wai Tak*, no. 16718 (C); prope vicum Fotsaogai in medio inter urbes Kanton et Lienping situm, alt. 400 m., *R. Mell*, no. 62, Jan. 2, 1920 (scandens; fr. lignosi brunnei) (AA). Kwangsi: 15 li south of Nee Bai, border of Kweichou, *R. C. Ching*, no. 6282, June 29, 1928 (AA, NY); Tsin-hung-shan, N. Hin-yen, *R. C.*

Ching, no. 6954, August 18, 1928 (AA). Western Szechuan: in thickets, Ya-chou, alt. 600–900 m., *E. H. Wilson*, no. 781, July & Dec. 1908 (climber, 5 m.; flowers white) (AA, G); Mt. Omei, *E. H. Wilson*, Veitch Exp. no. 5042, July 1904 (AA); in thickets, Nanchuan hsien, *W. P. Fang*, no. 5666, Oct. 30, 1928 (AA, NY). Yunnan: between Man-pieh and Man Lien, *J. F. Rock*, no. 2934, March 21, 1922 (scandent shrub with stiff, drooping branches; flowers white; fruits purple) (AA); beyond Lung Kai, watershed of Black River, or Papienho, *J. F. Rock*, no. 3069, April 5, 1922 (scandent shrubs with very fragrant, white flowers) (AA); between Tengyueh and Bhamo at the Yunnan-Burma border, *J. F. Rock*, no. 7833, December 1922 (scandent shrub) (AA); Mengtze, *A. Henry*, no. 940, Dec. 20 (shrub 1.5 m.) (NY); Szemao forests, alt. 1525 m., *A. Henry*, no. 11713 (large climber on trees; white flowers) (AA, NY); on scrub in thickets, hills east of Tengyueh, lat. 25° N., alt. 1830–2135 m., *G. Forrest*, no. 8072, June 1912 (scandent shrub 1.5–3.5 m.; flowers ivory-white, exterior dull crimson-lake, strongly fragrant) (AA); in open situations on trees in the Machang-kai valley, lat. 25° 30′ N., alt. 2135 m., *G. Forrest*, no. 11827, July 1913 (scandent shrub 3.5–6 m.; flowers waxy white, flushed rose exterior, fragrant) (AA). Annam: in thickets along river, Tourane, *J. & M. S. Clemens*, no. 3448, May–July 1927 (vine) (AA). Assam: jungle near Naga Hill, *Dr. D. Prain's collector*, no. 892, April 1899 (AA); Mausmai, Khasia and Jaintia Hills, alt. 1220 m., *L. F. Ruse*, no. 135, May 18, 1923 (shrubby climber, 6 m.; flowers white) (AA).

At first this species seemed a rather troublesome problem on account of its close relationship with *J. paniculatum* Roxb. and *J. pachyphyllum* Hemsley and the difficulty of definitely limiting any of the species.

Roxburgh in Flora Indica described both *J. lanceolarium* and *J. paniculatum*. The description of *J. lanceolarium* came first, was rather brief and signified only that the leaves were lanceolate and the "corymbs" terminal. Corymbs as used here proved to be an unfortunate term because all the species have open panicles. They often appear as corymbs because of the size and compactness of the flower clusters. Immediately following came the description of *J. paniculatum*. In this species "the leaflets are from oval to oblong with an obtuse point, polished and of hard texture. The flowers are small and white but numerous, on terminal pretty large open, brachiate panicles." These descriptions are both so very brief that no clue to the real identity of a plant can be had.

As a further complication, Hemsley later described the species

J. pachyphyllum which supposedly varied from "*J. paniculatum* which has narrower leaflets and distinctly pedicellate flowers." However, we have at hand material from the same locality, agreeing with Hemsley's description but possessing distinctly lanceolate leaves.

Fortunately we have sixty or more specimens of these three species in question. Included among them is an excellent photograph of the type of *J. pachyphyllum* and material collected from the type localities of the other species. At first, one is in a quandary just how to separate the species and draw a line of demarkation. The ample material at hand proved to be a salvation because it definitely proved that no distinct line can be drawn between these three species.

The greatest variation factor is leaf form. Here we find the gradation from distinctly lanceolate through ovate or elliptic-lanceolate to distinctly rotund or obtusely apiculate leaves. Furthermore these variations are found throughout the whole geographical range and not limited to individual regions which fact makes the retention of leaf forms as geographical varieties quite unadvisable. The geographical range is rather pronounced, extending from Assam and Indo-China north through all the provinces of China except those of northern China. However the series of gradation and intergradation of the characters used in limiting these species is so gradual and definitely marked that there is no doubt that the three species are all synonymous. It is very evident from the varying determination of duplicate numbers by eminent botanists that the workers were uncertain of these species and have been influenced in naming the specimens by geographical range, material at hand, previous determination and leaf shape.

8a. **Jasminum lanceolarium** Roxburgh var. **puberulum** Hemsley in Jour. Linn. Soc. XXVI. 78 (1889).—Rehder in Sargent, Pl. Wilson. II. 612 (1914).—Chung in Mem. Sci. Soc. China, I. 216 (1924).

Jasminum Dunnianum Léveillé in Fedde, Rep. Spec. Nov. XIII. 151 (1914).—**Syn. nov.**

H u p e h : ravines, north and south of Ichang, alt. 300–1000 m., *E. H. Wilson*, no. 781A, July and December 1907 (climber 7 m.; flowers white, fragrant) (AA, C); glen near Ichang, *E. H. Wilson*, Veitch Exped. no. 1018, June 1900 (climber with white flowers) (AA); foot of shaded cliff, Liang Sung Gon, alt. 780 m., *W. Y. Chun*, no. 3845, August 10, 1922 (woody vine with leaves light shiny green above, paler beneath) (AA); Ichang, *A. Henry*, nos. 2729, 3669 (G); without precise locality, *A. Henry*, nos. 3000

(AA) and 4562 (G). Kiangsi: circa carbonis minas Pinghsiang, alt. 600 m., *Wang Te Hui*, no. 202 in 1920 (flores albi) (AA). Chekiang: by the side of an exhausted stream, *Y. L. Keng*, no. 218, July 30, 1926 (trailing plant, woody and pubescent, about 2 m. long) (AA); valley along stream, Sungyang hsien, alt. 210 m., *H. H. Hu*, no. 426, September 20, 1920 (vine about 3–6 m. with greenish white berries) (AA); on dense bushy slopes, 60 li from Wenchow, *R. C. Ching*, no. 1890 (tough climber; flowers white and scented) (AA). Fukien: climbing over thickets in rocky ravine, Buong Kang, Yenping, alt. 700 m., *H. H. Chung*, no. 3585, June 27, 1925 (climber with white scented flowers) (AA, C). Kwantung: near Taiping, *W. Y. Chun*, no. 5670, Dec. 11, 1927 (on shrubs in open) (AA); Lok chong, *C. L. Tso*, no. 21001, June 6, 1929 (high climber, twining on trees; flowers white) (NY). Kweichou: Che-ten, *J. Esquirol*, no. 887, June 1906 (arbrisseau; fleurs blanches) (AA, type of *J. Dunnianum* Lévl.); inter oppida Kweiting et Tuyün, in silvis umbrosis, faucium prope vicum Madjiaduen, alt. 1100 m., *H. Handel-Mazzetti*, 206 (10649) August 9, 1917 (frutex sarmentosus fl. albis) (AA) Kwangsi: in woods, Bin-long, Miu-shan, N. Luchen, alt. 1220 m., *R. C. Ching*, no. 5970, June 14, 1928 (climber 6 m.) (AA).

Jasminum Dunnianum Léveillé is undoubtedly the same as *J. lanceolarium* var. *puberulum*. The variation from the straight species *J. lanceolarium* is only in the character of pubescence and not worthy of specific rank.

9. **Jasminum sinense** Hemsley in Jour. Linn. Soc. Bot. xxvi. 80 (1889).—Diels in Bot. Jahrb. xxix. 533 (1900).—Léveillé, Fl. Kouy-Tchéou, 294 (1914); in Fedde, Rep. Spec. Nov. xiii. 150 (1914).—Rehder in Sargent, Pl. Wilson. ii. 612 (1914).—Chung in Mem. Sci. Soc. China, i. 217 (1924).

Lonicera Rehderi Léveillé in Fedde, Rep. Spec. Nov. x. 145 (1911).—Non Merrill.—**Syn. nov.**

Lonicera Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. xi. 31 (1912).—**Syn. nov.**

Jasminum Bodinieri Léveillé in Fedde, Rep. Spec. Nov. xiii. 151 (1914).—**Syn. nov.**

Hupeh: mountains, Patung, *E. H. Wilson*, Veitch Exped. no. 1576, August 1900 (climber with white flowers) (NY); Nanto and mountains to the northward, *A. Henry*, no. 4464 (G, isotype). S. W. Hunan: in ditione oppidi Tsingtschou prope vicum Pukou, in fructicetis, alt. 400 m., *H. Handel-Mazzetti*, no. 336, July 30, 1917 (sarmentosa; fl. albi) (AA). Fukien: Hinghwa, *H. H. Chung*, no. 959 in 1923 (AA). Kwangtung: Hongkong, *C. Ford* (NY, P); Lin District, *C. O. Levine*, no. 3320, Oct. 14,

1918 (G). Kwangsi: Tsin-hung-shan, N. Hin-yen, alt. 220 m., climbing in thickets, *R. C. Ching*, no. 7023, August 19, 1928 (bark green; flowers white, scented) (AA, NY). Yunnan: mountains to the north, Mengtze, alt. 1525–1830 m., *A. Henry*, nos. 9657, 9657A, 9657B (climber with white flowers) (AA, NY); Szemao, alt. 1830 m., *A. Henry*, no. 13354 (climber with white flowers) (AA); on trees and scrub, flanks of the Mingkwong valley, lat. 25° 15′ N., alt. 2135 m., *G. Forrest*, no. 7861, May 1912 (scandent shrub 2.5–6 m.; flowers interior waxy white, exterior flushed crimson-rose, deliciously fragrant) (AA). Kweichou: Pan choui route de Pin-Fa a Tou-Yun, *J. Cavalerie*, no. 3038, April 9, 1907 (AA, type of *Lonicera Cavaleriei*); environs de Tsin-gay, Gan-pin, *Jean Laborde*, Sept. 1897 (arbuste, sarmenteux; fleurs jaunes (AA, type of *J. Bodinieri* Lévl.). Western Szechuan: in thickets, Ya-Chou-Fu alt. 600–900 m., *E. H. Wilson*, no. 2808, August and November, 1908 (climber, 3 m.; flowers white) (AA, G).

There is no doubt but that *Jasminum Bodinieri* Léveillé, *Lonicera Cavaleriei* Léveillé and its synonym *Lonicera Rehderi* Léveillé all belong to *J. sinense*.

Series 3. PINNATIFOLIA DC.

A. Calyx lobes subulate-setaceous, 5–8 mm. long.
  B. Flowers white.....10. *J. officinale*
  BB. Flowers pink.....11. *J. stephanense*
AA. Calyx lobes usually obtuse or if subulate not more than 1 mm. long.
  B. Leaflets distinctly trinerved.....12. *J. polyanthum*
  BB. Leaflets five-nerved.....13. *J. dispermum*

10. **Jasminum officinale** Linnaeus, Sp. Pl. I. 7 (1753).—Curtis in Bot. Mag. I. t. 31 (1787).—DeCandolle, Prodr. VIII. 313 (1844).—Brandis, Forest Fl. Brit. Ind. 313 (1874); Ind. Trees, 452 (1906).—Boissier, Fl. Or. IV. 43 (1879).—Clarke in Hooker f., Fl. Brit. India, III. 603 (1882).—Dippel, Handb. Laubholzk. I. 150 (1889).—Collett, Fl. Siml. 307 (1902).—Schneider, Ill. Handb. Laubholzk. II. 837, fig. 526 i-m, 527 d-e (1911).—Bailey, Stand. Cyclop. Hort. III. 1718, figs. 2008 (1915).—Rehder in Sargent, Pl. Wilson. II. 613 (1916); Man. Cult. Trees Shrubs, 765 (1927).—Chung in Mem. Sci. Soc. China, I. 216 (1924).

Jasminum vulgatum Lamarck, Fl. Franc, II. 306 (1778).
Jasminum viminale Salisbury, Prodr. 12 (1796).
Jasminum affine Lindley in Bot. Reg. XXXI. t. 26 (1845).

Yunnan: high plateau between Talifu and Likiang to the foot of the Likiang Snow Range, *J. F. Rock*, nos. 3190, 3244 and 3312, May 6–11, 1922 (climber; flowers white with purple tubes) (AA); Pe-long-tsin, alt., 3200 m., *E. E. Maire*, no. 3352 ser. B, June 1910 (fleurs blanches) (NY, P); on scrub on the descent to

the Yangtze, from the eastern boundary of the Lichiang valley, lat. 27° 15′ N., alt. 2740 m., *G. Forrest*, no. 10107, June 1913 (scandent shrub 1.5–4 m.; flowers white, exterior dull rose, fragrant) (AA); in rupibus calcareis, in summa Lan tsching shan, Yunnan fu, alt. 2400 m., *O. Schoch*, no. 206, June 15, 1916 (flores rubicundi) (AA). Szechuan: open rocky, dry situation around Mu-li, lat. 28° 12′ N., long. 100° 50′ E., alt. 2135–2440 m., *G. Forrest*, no. 20417, June 1921 (shrub 0.5–1.0 m.; flowers fragrant, white, flushed purple exterior) (AA); exact locality lacking, ravine, alt. 2740 m. *E. H. Wilson*, Veitch Exped. no. 4074A, June 1904 (flowers white) (AA); Monkong Ting, alt. 2300–2600 m., *E. H. Wilson*, no. 2807, June 1908 (climber 2–3 m., flowers white, fragrant) (AA, G); Te chang, *C. K. Schneider*, no. 702, April 3, 1914 (AA); inter Yenyuan tsien and Hunka, alt. 3800 m., *C. K. Schneider*, no. 1474, June 12, 1914 (flowers white flushed with red) (AA). Southeastern Tibet: on scrub and in thickets in side valleys on the Salween-Kiu-chiang divide, Tsarong, lat. 28° 40′ N., long. 98° 15′ E., alt. 1830–2135 m., *G. Forrest*, no. 19296, August 1919 (scandent shrub 6–9 m., flowers strongly fragrant, white, flushed deep rose exterior) (AA). British India: Langera, Bhandal Valley, Chamba State, alt. 2200 m., *R. N. Parker*, Oct. 2, 1919 (AA); Bhabua village, West Nepal, *Bis Ram*, no. 452, May 21, 1929 (climbing shrub) (AA); Kumaon, *Dr. J. F. Royle*, date and number lacking (G); Panjab, *T. Thomson*, number and date lacking (G); Malabar, Concav, *Stocks, Law and ?* (G).

[193] 10a. **Jasminum officinale** Linnaeus forma **grandiflorum** (Linnaeus), comb. nov.

Jasminum grandiflorum Linnaeus, Sp. Pl. ed. 2, I. 9 (1762);—Ker in Bot. Reg. II. t. 91 (1816).—Roxburgh, Fl. Ind. I. 98 (1820).—DeCandolle, Prodr. VIII. 313 (1844).—Wight, Ic. Pl. Ind. Or. IV. t. 1257 (1848).—C. B. Clarke in Hooker f., Fl. Brit. Ind. III. 603 (1882).—Bailey, Cycl. Am. Hort. II. 843 (1900); Stand. Cycl. Hort. III. 1718 (1916).—Léveillé in Fedde, Rep. Spec. Nov. XIII. 150 (1914).—Chung in Mem. Sci. Soc. China, I. 216 (1924).

Jasminum officinale grandiflorum Anon. in V. Lemoine et Fils (Catalogue) no. 173, p. 14 (1909).—nomen nudum.

Yunnan: open moist situation by sides of streams in the Tali Range, lat. 25° 40′ N., alt. 2135–2440 m., *G. Forrest*, no. 4683, May–June 1906 (shrub 2–4 m.; flowers exterior rose, interior white, fragrant) (AA); haies des coteaux derrière Tong-tchouan, alt. 2600 m., *E. E. Maire*, no. 7188 collected in May (grimpant; fleurs blanches) (C); on cliffs, Pu-esh, alt. 1525 m., *A. Henry*, no. 13397 (climber with white flowers) (AA, NY). N. India: Kashmir: Hariwan stream, alt. 1615 m., *G. A. Gamme*, July 10, 1891 (plant 1 m.) (AA); Ganderbal-Kangan, alt. 1830 m., *R. R.*

Stewart, no. 6228, July 14, 1921 (AA); Domel Thelum Valley, alt. 750 m., *Keshavanam*, no. 657, June 1907 (AA). Punjab: Taranda, Badhahr State, Simla District, alt. 1800 m., *R. N. Parker*, no. 2979, June 10, 1928 (AA). Western Himalaya: Kamálhan, Kagán, *Ináyat*, June 17, 1899 (AA); Sultánpur on the Biás River, Prov. Kulu, *Herb. W. J. Hooker*, Cat. no. 12246, June 5, 1856 (G); Kumaon, alt. 1220 m., *R. Strachey and J. E. Witherbottom*, no. 5 (G). Burma: Tenasserim and Andamans, *J. W. Helfer*, no. 3718 (G); precise locality lacking, *R. Wight*, no. 1752 (G).

The species *J. officinale* L. and the erstwhile *J. grandiflorum* L. offered considerable difficulty in attempted specific delimitation. No character or group of characters held together consistently enough to permit definite separation. In examining the copious material at hand (both spontaneous and cultivated) it was found that there was a definite gradation in all the diagnostic characters from the larger-flowered forms to the small-flowered specimens; from the longer, lanceolate leaflets to the smaller cuspidate forms; from the long subulate-setaceous calyx teeth to the less conspicuous calyx teeth; in fact, on a single flower cluster were found enough differentiation in calyx teeth length sufficient to be used in specific limitation. However, some specimens, especially those in cultivation presented a larger, more showy flower development. This form is very much cultivated in gardens under the name *J. grandiflorum* and as a result, it seems best, if for this purpose alone, to retain the name *grandiflorum* as a horticultural form of *J. officinale*.

11. × **Jasminum stephanense** V. Lemoine and Son (Cat.) no. 195, p. 9, pl. (1921).—A. Meunissier in Rev. Hort. 1927, p. 643, t.—Mrs. J. N. Henry in Horticulture, VIII. 486, fig. (1930). = *J. Beesianum* × *officinale* f. *grandiflorum*.

Jasminum officinale grandiflorum × *J. Beesianum* Anon. in Jour. Soc. Nat. Hort. France, ser. 4, XXI. 224 (1920).

Yunnan: Yangtze watershed, Prefectural District of Likiang, eastern slopes of Likiang Snow Range, *J. F. Rock*, no. 4509, May-Oct. 1922 (flowers entirely pink) (AA, NY).

This hybrid between *J. officinale grandiflorum* and *J. Beesianum* was first exhibited as an artificial hybrid by M. Thomas Javit at the Flower Show of the Société Nationale d' Horticulture de France in July 1920. Until recently it had not been known as a natural hybrid. However, it is interesting to know that this beautiful hybrid Jasmine combining the attractive coloring of *J. Beesianum* with the fragrance of its other parent was collected by Rock in Yunnan almost at the same time of its presentation to the public in artificial form. Besides the spontaneous specimen of J. F. Rock,

material collected from a plant given the Arboretum by Mrs. J. N. Henry of Gladwyne, Pa., was obtainable also. Mrs. Henry says that the plant grows luxuriously at both her Pennsylvania and Maryland homes. Unfortunately it is not hardy as far north as Massachusetts. An excellent flowering specimen collected at the Vilmorin Nurseries at Verrières is in the herbarium of the Arnold Arboretum.

The name stephanense refers to Saint-Etienne, the place where the hybridization was made; Stephanus being the latin equivalent of Etienne.

12. **Jasminum polyanthum** Franchet in Rev. Hort. 1891, p. 270, fig. 69; Léveillé in Fedde, Rep. Spec. Nov. XIII. 150 (1914).—Chung in Mem. Sci. Soc. China, I. 216 (1924).

Jasminum Blinii Léveillé in Fedde, Rep. Spec. Nov. XIII. 151 (1914); Cat. Pl. Yun-nan 179 (1916).—**Syn. nov.**

Jasminum Delafieldii Léveillé, Cat. Pl. Yunnan 179 (1916).—**Syn. nov.**

Yunnan: Mengtze, alt. 1525 m., *A. Henry*, no. 10314 (AA); Chu-yuan, *A. Henry*, no. 10314A (AA); Kon ya hua, Mengtze woods, alt. 1400 m., *A. Henry*, no. 10314B ("dog's tooth flower"; large climber; flowers with white lobes and pink corolla tubes; strong odor, worn by women for adorning the hair) (AA, NY); mountain forests, Szemao, alt. 1525 m., *A. Henry*, no. 11656 (climber with white flowers) (AA); in collibus calcareis, Yunnan fu, alt. 2000–2200 m., *O. Schoch*, no. 18, April 24, 1916 (frutex valde scandens) (AA); amongst scrub in the Tali valley and along the base of the eastern flank of the Tali Range, lat. 25° 40′ N., alt. 2040–2440 m., *G. Forrest*, no. 4658, May–August 1906 (weakly scandent shrub 2–3 m.; flowers, interior white, exterior rose, strongly fragrant) (AA); on scrub in open situations, hills around Tengyueh, lat. 25° N., alt. 1675–2135 m., *G. Forrest*, no. 9761, March 1913 (scandent shrub 2–6 m.; flowers, interior white, exterior red) (AA); haies de Tso-si, alt. 2900 m., *E. E. Maire* (AA no. 253) April 19— (arbuste grimpant à longs rameaux toujours verts; fls. branches levées de rose) (AA); Yunnan-fu, alt. 2200 m., *Harry Smith*, no. 1622, Sept. 4, 1922 (flores rosei) (AA); haies de Ma-Tchang près Tchen-Lin, *J. Esquirol*, April 28, 1906 (très belle fleur pendant en longs festons, rosée à l'interieur) (fragment and photo of type of *J. Delafieldii* in AA, type at E); precise locality lacking, *F. Ducloux*, nos. 58, 800 (NY). Kweichou: Gan-chouen, *J. Cavalerie*, no. 3912, May 1912 (liane; fleurs blanchâtres) (AA, G) (iso-syntypes of *J. Blinii*).

The two species *Jasminum Blinii* and *J. Delafieldii* described by Léveillé are found on careful study to be conspecific with *J. polyanthum* Franchet.

13. **Jasminum dispermum** Wallich in Roxb. Fl. Ind. ed. Carey, I. 99 (1820); Pl. As. Rar. III. t. 274 (1832).—D. Don, Prodr. Fl. Nepal. 106 (1825).—DeCandolle, Prodr. VIII. 310 (1844).—Brandis, For. Fl. Brit. Ind. 313 (1874).—C. B. Clarke in Hooker f., Fl. Brit. Ind. III. 602 (1882).—Duthie, Fl. Upper Gangetic Plain, II 23 (1911).—C. J. Bamber, Pl. Punjab, 588 (1916).—Parker, For. Fl. Punjab, Hazara and Delhi, ed. 2, 320 (1924).—Ostwaston, For. Fl. Kumaon, 335 (1927).

Jasminum quinquinerve Lambert ex D. Don, Prodr. Fl. Nepal. 106 (1825).

Yunnan: watershed of the Black River or Papienho, between Mohei and Maokai beyond Chugai, alt. 2040 m., *J. F. Rock*, no. 3016, April 7, 1922 (scandent shrub, 3–4.5 m.; flowers white inside, purplish red outside; drupes blackish blue) (AA); on the Shweli-Salween divide, lat. 25° 30′ N., alt. 2040 m., *G. Forrest*, no. 15720, July 1917 (AA). British India: Sanpra, West Nepal, *Bis Ram*, no. 460, May 23, 1929 (climber) (AA); Katai, West Nepal, *Bis Ram*, no. 124, Mar. 28, 1929 (AA); Camp Dharamsala, Distr. Kangra Punjab, *Bis Ram*, no. 326, June 6, 1928 (AA); Sikkim, alt. 1500 m., *G. King*, Feb. 19 and March 24, 1876 (AA); Sikkim, alt. 1500–1560 m., *J. D. Hooker* (G); Himalaya bor. occidentalis, alt. 1800–2400 m., *T. Thomson* (G); in hedges on road from Chuari to Sihunta, Bhatiyat Wagirat, Chamba State, alt. 900–1050 m., *R. N. Parker*, Oct. 1, 1920 (AA); Konoma, Assam, alt. 1500 m., *Dr. King's Collector*, no. 220, April 1896 (AA); Lyndoh Forest, Mawphlang, K. and J. Hills, Assam, alt. 1800 m., *Upendranath Kanjilal*, no. 4656, Oct. 22, 1914 (AA); Kumaon, alt. 2100 m., *R. Strachey and J. E. Winterbottom*, no. 6 (G); Mussoonia, Siwalik and Jaunsar Divisions, Chandan, *Singh Rawat* no. 76, June 9, 1921 (scandent shrub) (AA).

Series 4. UNIFOLIOLATA DC.

A. Calyx lobes diminutive, obtuse, not subulate-setaceous.
  B. Corolla 35 mm. (in toto); tube 25 mm. long; leaf 18 cm. long, 8 cm. wide. ..... 14. *J. coffeinum*
  BB. Corolla about 25 mm. long or less; leaves hardly ever over 4 cm. wide, usually considerable less.
    C. Inflorescence terminal, a many-flowered, diffuse cyme, up to 10 cm. wide, corolla tube and lobes (linear) nearly equal. 15. *J. Seguinii*
    CC. Inflorescence terminal and axillary, usually in close clusters; corolla tube considerably longer than lobes (acute).
      D. Leaves usually 9–16 cm. long, 3–4 cm. wide, lanceolate or oblong lanceolate; Western China (Yunnan). 16. *J. dumicolum*
      DD. Leaves 3.5–8.5 cm. long, 1.5–4 cm. wide, ovate; Eastern China (Kwantung). ..... 17. *J. microcalyx*

AA. Calyx lobes subulate-setaceous.
B. Calyx glabrous.
C. Leaves coriaceous or sub-coriaceous.
D. Fruit yellow; leaves lanceolate.....18. *J. Prainii*
DD. Fruit black; leaves ovate.....19. *J. pentaneurum*
CC. Leaves not coriaceous.
D. Flowers red; fruit yellow.....20. *J. Beesianum*
DD. Flowers white; fruit black.....21. *anastomosans*
BB. Calyx pubescent.
C. Leaves and branchlets flavescent; leaves 2–4 cm. long, chartaceous. 22. *J. nintooides*
CC. Leaves glabrous or pubescent, not flavescent, seldom less than 6 cm. long.
D. Leaves very thin, membranaceous, reticulations outstanding on upper surface and lower surface; flowers double. 23. *J. sambac*
DD. Leaves not particularly thin, some near coriaceous, upper surface not noticeably reticulate.
E. Stem leaves cordate at base.....24. *J. multiflorum*
EE. Stem leaves cuneate or truncate at base.
F. Leaves distinctly cuneate at base.....25. *J. coarctatum*
FF. Leaves truncate, or nearly so at base; not cuneate. 26. *J. amplexicaule*

14. **Jasminum coffeinum** Handel-Mazzetti in Anz. Akad. Wiss. Wien, LXII. 235(Pl. Nov. Sin. Forts. 37; p. 2) (1925).

Yunnan: In bambusetis et silvis apertis tropicis ex adverso supra vicum Manhao prope fines Tonkinensis, substr. schisto argilloso, alt. 200 m., *H. Handel-Mazzetti*, no. 5827, March 1, 1915 (flores albi extus rubri) (isotype in AA).

15. **Jasminum Seguinii** Léveillé in Fedde, Rep. Spec. Nov. XIII. 151 (1914).

Jasminum taliense, W. W. Smith in Notes Bot. Gard. Edinb. XII. 210 (1920).—**Syn. nov.**

Kweichou: Rochers de la cascade aux environs de Hoang-Ko-Tchou, *J. Seguin*, in herb. E. Bodinier, no. 2354 June 9, 1898 (arbuste liane; fleurs blanches) (isotype in AA). Yunnan: on scrub and trees, western flank of the Tali Range, lat. 25° 40′ N., alt. 3050 m., *G. Forrest*, no. 11667, Aug. 1913 (scandent shrub 2–3 m.; flowers fragrant, interior creamy white, exterior flushed crimson) (isotype of *J. taliense* in AA, C); amongst scrub, western flank of the Tali Range, lat. 25° 40′ N., alt. 2740 m., *G. Forrest*, no. 15605, July 1917 (semi-scandent shrub 2–3 m.; flowers white with flushed rose exterior, fragrant) (isotype of J. taliense in AA); on scrub in thickets on the N'Maikha-Salwin divide, lat. 26° 20′ N., alt. 2740 m., *G. Forrest*, no. 18330, August 1919 (scandent shrub 3–3.5 m.; flowers white, exterior, faintly flushed rose fragrant) (AA); in thickets by streams in side valleys on the Chien-chuan-Mekong divide, lat. 26° 30′ N., long. 99° 40′ E., alt. 2135–

2440 m., *G. Forrest*, no. 23166, July 1922 (scandent shrub 2–6 m.; flowers white with flushed purple-rose exterior, fragrant) (AA); south forests, Szemao, alt. 1525 m., *A. Henry*, nos. 12661 and 12661A (large climber with white flowers) (AA, NY); in valle fluminis Yangtze, prope Ta ku, alt. 2500 m., *C. K. Schneider*, no. 2150, August 1914 (fl. albo-flavi) (AA); ex colle Tong chan, Tie So, *Simeon Tén*, no. 131, May 30, 1916 (frutex prostrata ad 1 m.; floribus albi) (AA); Yangpi road in mountains of the Yangpi river drainage basin, *J. F. Rock*, no. 6214, August 1922 (flowers white, fragrant) (AA); Mengtze, *A. Henry*, nos. 9581, 9581B, 9581C (climbing shrub 1–1.5 m.; flowers white; fruit black) (AA, NY); dry forest edge of paddy plain, Muang Hun, *J. F. Rock*, no. 2440, Feb. 14, 1922 (woody vine with scandent branches) (AA). Szechuan: inter pagum Telipu et flumen Yalung, alt. 2000 m., *C. K. Schneider*, no. 1137, May 5, 1914 (frutex sub-scandens; fl. albi, valde odorati) (AA).

There seem to be no difference between the two types to warrant specific delimitation.

16. **Jasminum dumicolum** W. W. Smith in Notes. Bot. Gard. Edinb. XII. 207 (1920).

Jasminum Schneideri Léveillé, in herb.

Yunnan: among scrub, Shweli Valley, lat. 25° N., alt. 1525–1830 m., *G. Forrest*, no. 7926, May 1912 (shrub 2–3 m.) (isotype in AA); on scrub and trees, hills to the east of Tengyueh, lat. 25° N., alt. 1830–2135 m., *G. Forrest*, no. 8094 (scandent shrub 2–3 m.) (isotype in AA); on trees and scrub in rather shady situations, western flank of the Shweli-Salween divide, lat. 25° 10′ N., alt. 2440–2740 m., *G. Forest*, no. 9346, Dec. 1912 (scandent shrub 3–5 m.; flowers exterior deep crimson rose, interior white or flushed rose, fragrant) (isotype in AA); on trees, Ma-chang-kai Valley, north of Tengyueh, lat. 25° 20′ N., alt. 1830 m., *G. Forrest*, no. 9531, Feb. 1913 (scandent shrub 6–9 m.; flowers interior white, exterior dull rose, fragrant) (isotype in AA); on scrub, Ma-chang-kai Valley, lat. 25° 20′ N., alt. 1830–2135 m., *G. Forrest*, no. 9757, March 1913 (scandent shrub 2–3.5 m.; flowers interior creamy white, exterior deep dull crimson) (isotype in AA); mountain forests, Mengtze, alt. 1525 m., *A. Henry*, no. 10634A (large climber) (isotype in NY); Szemao, *A. Henry* 11708 (large climber) (NY); at Kao shan ssu, Shweli River drainage basin to summit of Shweli-Salween watershed, east of Tengyueh, *J. F. Rock*, no. 7894, Nov. 1922–March 1923 (climber; flowers white inside, purplish outside, fragrant) (AA); environs de Mý tsaô, *F. Ducloux*, no. 112, March 4, 1897 (tiges s'enlaçant aux arbores et buissons; fleurs blanches,

boutons roses) (AA; photo. and fragments of type of *J. Schneideri* Lévl. from E).

17. **Jasminum microcalyx** Hance in Jour. Bot. XXI. 323 (1883).—Hemsley in Jour. Linn. Soc. London, XXVI. 79 (1889).—Léveillé in Fedde, Rep. Spec. Nov. XIII. 149 (1914).—Chung in Mem. Sci. Soc. China, I. 216 (1924).—Merrill in Lingnan Sci. Jour. V. 147 (1927).

Jasminum inornatum Hemsley in Jour. Linn. Soc. XXVI. 78 (1889).—Léveillé in Fedde, Rep. Spec. Nov. XIII. 149 (1914).—Chung in Mem. Sci. Soc. China, I. 216 (1924).—**Syn. nov.**

Hainan: Hoi-hau, *B. C. Henry*, no. 22171 (Hance Herb.) Oct. 19, 1882 (type; photo. in AA, carbon tracing in NY); in dry thickets, Hoihau, *F. A. McClure*, no. 7595, Oct. 10, 1921 (bushy vine with fragrant, white flowers) (NY). Kwantung: without precise locality, *C. Ford*, no. 113 (type; photo. in AA, carbon tracing in NY).

Although little known, the species *J. microcalyx* is quite outstanding in its nearly obsolete calyx-lobes. Hemsley's *J. inornatus* described six years later is conspecific with *J. microcalyx*.

18. **Jasminum Prainii** Léveillé in Fedde, Rep. Spec. Nov. X. 148 (1911); XIII. 151 (1914).

Kweichou: route de Pin-fa ad Ou-glan *J. Cavalerie*, August 1908 (E, type; AA, isotype).

There is a superficial resemblance between *J. Prainii* Léveillé and *J. dumicolum* W. W. Smith. However, *J. dumicolum* possesses calyx-lobes of a more obtuse nature while *J. Prainii* has calyx lobes distinctly subulate-setaceous.

19. **Jasminum pentaneurum** Handel-Mazzetti in Anz. Akad. Wiss. Wien, LIX. 110 (Pl. Nov. Sin. Forts. 16, p. 9) (1922).

Kwantung: In monte Dingwu-schan ad occid. urbis Kanton, *R. Mell*, no. 215 March 26, 1918 (photo. of type in AA); in montibus Lungtou-schan loco Siuhang dicto, alt. 300 m., *R. Mell*, no. 922, Nov. 18, 1917 (fragment of type in AA); Loting, *Y. Tsiang*, no. 1143, Sept. 14, 1928 (AA, NY); on side of river, Ting Wu Shan, *Y. Tsiang*, no. 1490, Nov. 5, 1928 (scandent) (AA, NY); in dense mixed woods, Kochow District, *Y. Tsiang* no. 2244A, May 11, 1929 (AA); Tseh Tse Dee, West River, Yun Fou district, *Y. K. Wang*, no. 321, Jan. 14, 1928 (AA); on roadside, Yun Fou District, *Y. K. Wang*, no. 1832, Feb. 12, 1929 (NY); in mixed woods, Ting Wu Shan, *W. Y. Chun*, no. 6344, May 5, 1928 (scandent) (AA); in valley, Tsing Yun District, *W. Y. Chun*, no. 30472, March 23, 1930 (suffruticose) (NY); scattered along trail near stream above

monastery, Ting Woo Mts., alt. 300 m., *C. O. Levine*, no. 2016, May 26, 1918 (C); Poon Yue District, *Ah To*, Hb. no. 3177, Oct. 30, 1918 (flowers white) (C); same locality, *C. O. Levine*, Hb. no. 3180, Nov. 1, 1918 (AA); Ting Woo Mt., *C. O. Levine & G. W. Groff*, no. 42, Nov. 18, 1916 (AA); in woods, Teng wu shan, *H. T. Ho*, no. 60041 (shrub) (NY); exact data lacking, *G. Ford*, (NY). Kwangsi: Bako-shan, W. Poseh, alt. 900 m., *R. C. Ching*, no. 7521, Sept. 18, 1928 (tough straggling climber on trees, 9 m.; flowers white, star shaped) (AA).

This recently described species although quite outstanding and frequently collected especially in Kwangtung has been usually identified with *J. laurifolium* Roxb., *J. subtriplinerve* Bl. and *J. nervosum* Lour. The two former species are probably confined to the Himalayan region only, while the latter, *J. nervosum* Lour. seems to be of rather dubious status and closely allied to *J. anastomosans*. This would seem to account for the seeming confusion.

20. **Jasminum Beesianum** Forrest & Diels in Notes Bot. Gard. Edinb. v. 253 (1912).—Léveillé, Fl. Kouy-Tchéou, 293 (1914); in Fedde, Rep. Spec. Nov. XIII. 149 (1914).—Rehder in Sargent, Pl. Wilson. II. 615 (1916).—Chung in Mem. Sci. Soc. China, I. 216 (1924).

Jasminum Wardii Adamson in Jour. Bot. LI. 131 (1913).—**Syn. nov.**

Jasminum Delavayi Franchet ex Diels in Notes Bot. Gard. Edinb. V. 253 (1912), in obs.

Jasminum Valbrayi Léveillé in Fedde, Rep. Spec. Nov. XIII. 337 (1914). —**Syn. nov.**

Jasminum violascens Lingelsheim in Fedde, Rep. Spec. Nov. Beih. (Limpricht, Bot. Reise Hochgebirg. China & Ost-Tibet) XII. 463 (1922).—**Syn. nov.**

Yunnan: amongst rocks and stone on dry, barren, open ground at south end of the Sung-kwei valley, lat. 26° 20′ N., alt. 2440–2740 m., *G. Forrest*, no. 2021, April 1906 (shrub to 1 m.; flowers pink or deep rose, strongly fragrant) (AA, isotype); Li-chiang Range, lat. 27° 15′ N., alt. 2740–3200 m., *G. Forrest*, no. 10066, June 1913 (AA); around Pe Yen Tsin (Tong-tschoun) *Simeon Tén*, no. 499, April 5, 1919 (prostrate shrub with red flowers) (AA); in dumetis ad vicum Djuandjiadjio et Tschapoling prope oppidum Sidsung, alt. 1900–2000 m., *H. Handel-Mazzetti*, no. 20, June 9, 1917 (fruticulus subscandens: fl. intense rosei) (AA); ad pedem montium niveosorum prope Lichiang in dumetis ad rivulos, alt. 2900 m., *C. K. Schneider*, no. 3199, Oct. 1914 (AA); in regione Lichiang prope pagum Ngu Leh keh, alt. 2900 m., *C. K. Schneider*, no. 2082, July 31, 1914 (scandens) (AA); climbing over Roses on high plateau between Talifu and Likiang to the foot of the Likiang Snow Range, *J. F. Rock*, no. 3216, May 6–11,

1922 (AA, NY); in summa montis Mangan in rupibus calc., alt. 2400 m., *O. Schoch*, no. 207, May 26, 1916 (AA); haies-plaine de Tong tchouan, alt. 2500 m., *E. E. Maire* (AA no. 108) (arbrisseau grimpant toujours; fl. carmine) (AA); haies de la plaine à Tong-tchouan, alt. 2500 m., *E. E. Maire*, no. 3310, May 1911 (fl. rouge pourpre) (NY, C); haies, plaine de Tong-tchouan, alt. 2500 m., *E. E. Maire*, May 1913 (fleurs d'un rouge carmin) (AA, isotype of *J. Valbrayi*); precise data lacking, *E. E. Maire*, no. 7417 (NY); precise data lacking, *F. Ducloux*, no. 6 (K) and no. 483 (AA). Szechuan: in prato herboso, Teng-ksiang-ying, alt. 2100 m., *Harry Smith*, no. 1886, May 20, 1922 (frutex humilis ad 3 dm. altus; flor. roseis-rubris) (AA); near Si tchi, Ning yuan fu, *C. K. Schneider*, no. 905, April 15, 1914 (AA); Lololand, östlich von Chao kio bei heisser Quelle, *C. K. Schneider*, no. 973, April 23, 1914 (AA); precise locality lacking, ravine, alt. 900–1830 m., *E. H. Wilson*, Veitch Exped. no. 4074, June 1904 (climber with rose flowers) (AA). East Tibet: Dawo, Tal von Lumpu, alt. 3900 m., *Dr. Wolfgang Limpricht*, no. 2006, July 15, 1914 (AA, photo. of type of *J. violascens* deposited at Herb. Breslau).

Jasminum Beesianum Forrest & Diels is probably one of the most outstanding species in the genus. Its distinctly ovate, attenuate leaves and its red flowers make it noticeably different. Adamson in describing *J. Wardii* was just one year later than Forrest and Diels in publishing his description of the species. Although not having seen the type of *J. Wardii*, another specimen collected by F. Ducloux and mentioned in the description by Adamson was loaned us by Kew and proves to be identical with *J. Beesianum*.

J. Delavayi Franchet as stated by Diels in an explanatory paragraph supplementing the original description of *J. Beesianum* is merely a name on a specimen in the Paris Herbarium collected by Bonvalot and the Prince of Orléans, between Batang and Litang in a humid valley on June 19th.

Photographs of the types of *J. Valbrayi* Léveillé and *J. violascens* Lingelsheim are in Arnold Arboretum herbarium. All these names mentioned above are clearly synonyms of *J. Beesianum*.

21. **Jasminum anastomosans** Wallich, Cat. 2863 (1829), nomen nud.—Kurz, For. Fl. Brit. Burma, II. 152 (1877).—DeCandolle, Prodr. VIII. 305 (1844).—C. B. Clarke in Hooker f., Fl. Brit. Ind. III. 596 (1882).—Léveillé in Fedde, Rep. Spec. Nov. XIII. 149 (1914).—Chung in Mem. Sci. Soc. China, I. 216 (1924).

? *J. nervosum* Loureiro, Fl. Cochinch. I. 20 (1793).

Yunnan: Szemao, alt. 1370 m., *A. Henry*, no. 11969, April

26 (climber on shrubs; white flowers) (AA, NY); between Keng Hung and Muang Hing, above Pang Khun, alt. 1380 m., *J. F. Rock*, no. 2611, Feb. 26, 1922 (twiner among tree branches) (AA); dry jungle, plain of the Keng Hung, alt. 750 m., *J. F. Rock*, no. 2507, Feb. 17, 1922 (stems dark green with a blackish tinge; petals pinkish) (AA). Kwangsi: in bush, I-shan, alt. 210 m., *R. C. Ching*, no. 5175, May 22, 1928 (AA). Kwantung: on open, extensive plain, Pon-tan, Luichow, alt. 210 m., *Y. Tsiang*, no. 2544, June 2, 1929 (scandent vine with white flowers) (AA, NY); on shrub in village common and roadside, Hainan, *F. A. McClure*, no. 9193, April 20, 1922 (vine 2–4 m.; flowers white, fragrant; fruits purple, black when ripe) (AA); Hainan, *A. Henry*, no. 8456, Nov. 1889 (G); Hainan, *Katsumatra* (Hongkong Herb. no. 5406) (C); in dense mixed woods, Koliangling, Kochow, alt. 255 m., *Y. Tsiang*, no. 2221, May 10, 1929 (scandent vine) (NY); same locality, *Y. Tsiang*, no. 2244, May 11, 1929 (scandent vine) (NY).

The synonymy of this species is rather difficult to express because of the fact that *J. anastomosans* has usually been considered a Himalayan rather than a Chinese species. C. B. Clarke in Hooker's Flora of British India lists *J. stenopetalum* Lindley, *J. trinerve* Roxburgh and *J. laurifolium* Wallich, non Roxburgh, as synonyms of *J. anastomosans*. Although these last named may be true synonyms of *J. anastomosans* they have not been treated as such in this paper because none of the type specimens or, in fact, any specimens bearing these determinations have been seen by the author.

J. nervosum Loureiro which is questionably cited under this species has heretofore been considered a good Chinese species. However, in examining the material so labeled one finds that the majority of specimens belong to *J. pentaneurum* Hand.-Mazz. leaving only a few sheets to this species. The original description is rather confusing and probably the cause of most of the misunderstanding because it is quite impossible to understand from it just what Loureiro intended as *J. nervosum*. He refers to the leaves as "folia impari pinnata." This, of course, would eliminate *J. nervosum* from the section Unifoliolata unless the small lateral branches were here mistaken for compound leaves. In this case, his description would read folia pari pinnati because of the terminal pair of leaflets. No type or authentic material seems to be available so *J. nervosum* is best treated here as a dubious synonym of its most closely allied species.

Confused with this same group of specimens was the Himalayan

species *J. laurifolium* Roxburgh. A single specimen collected by one of Dr. Prains' collectors, no. 885 made in the jungle near Naga Hill in Assam in April 1899 answers the original description made by Roxburgh and agrees well with an illustration in Botanical Register VII. t. 521 (1821). *Jasminum laurifolium* probably is then distinctly a Himalayan species and one not to have more than a nominal inclusion here.

Léveillé described in Fedde, Rep. Spec. Nov. XIII. 151 (1914) a new variety, *J. laurifolium* Roxb. var. *villosum*. This is probably a variety of *J. anastomosans*. Undoubtedly he was working with material of *J. anastomosans* incorrectly labeled *J. laurifolium* and had this in mind when he described his new variety. A very fragmentary specimen (in fact, only a leaf and a single flower) of the type is at present in the herbarium of the Arnold Arboretum. It seems to agree with *J. anastomosans* in all respects save its pubescent character. However, although there is quite a positive feeling that the material is a variation of *J. anastomosans* one hardly feels justified in making the actual variety transfer on such sparse evidence.

22. **Jasminum nintooides** Rehder in Sargent, Pl. Wilson. II. 615, 1916.—Chung in Mem. Sci. Soc. China, I. 216 (1924).

Yunnan: trailing and climbing over rocks, Mengtsze, alt. 1600 m., *A. Henry*, nos. 9433, type (AA, NY) and 9433A, 9433B (flowers white) (AA).

23. **Jasminum sambac** (L.) Aiton, Hort. Kew. I. 8 (1789).—Willdenow, Sp. Pl. I. 35 (1797).—Edwards in Bot. Reg. I. 1 (1815).—Wallich, Cat. n. 2868 (1829).—DeCandolle, Prodr. VIII. 301 (1844).—C. B. Clarke in Hooker f., Fl. Brit. Ind. III. 591 (1882).—Hemsley in Jour. Linn. Soc. XXVI. 80 (1889).—Bailey, Cycl. Am. Hort. II. 843 (1900); Stand. Cycl. Hort. III. 1717 (1915).—Léveillé in Fedde, Rep. Spec. Nov. XIII. 149 (1914).—Chung in Mem. Sci. Soc. China, I. 216 (1924).

Nyctanthes Sambac Linnaeus, Sp. Pl. I. 6 (1753).

Nyctanthes undulatum Linneaus, Sp. Pl. I. 6 (1753).

Jasminum bicorollatum Noronha in Verh. Batav. Gen. v. ed. 1, art. IV. 19 (1790).

Jasminum odoratum Noronha in Verh. Batav. Gen. v. ed. 1, art. IV. 19 (1790).

Mogorium Sambac Lamarck, Encycl. Méth. IV. 210 (1796); Ill. I. t. 6, fig. 1 (1823).

Mogorium undulatum Lamarck, Encycl. Méth. IV. 212 (1796).

Jasminum fragrans Salisbury, Prodr. 12 (1796).

Jasminum Zambac Roxburgh, Hort. Beng. 3 (1814), nomen; Fl. Ind. I. 87 (1820).

Jasminum pubescens Buchanan-Hamilton ex Wallich, Cat. sub no. 2880 (1829), nomen.—Jackson, Ind. Kew. I. 1250 (1893), as syn. of *J. sambac*.

Jasminum quadrifolium Buchanan-Hamilton ex Wallich, Cat. no. 2868 (1829), nomen.—Jackson, Ind. Kew. I. 1250 (1893), as syn. of *J. sambac.*

Jasminum quinqueflorum Heyne ex Wallich, Cat. no. 2878 (1829), nomen.—Jackson, Ind. Kew. I. 1250 (1893), as syn. of *J. sambac.*

Jasminum undulatum Hort. Heyne ex Wallich, Cat. No. 2871 (1829), nomen.—Jackson, Ind. Kew. I. 1251 (1893), as syn. of *J. sambac.*

Jasminum Heyneanum Wallich, Cat. no. 2871 (1829), nomen.—Jackson, Ind. Kew. I. 1250 (1893), as syn. of *J. sambac.*

Jasminum sambuc Wight, Ic. II. t. 704 (1843).

Kwangsi: Moo-shan, Luchen, alt. 540 m., *R. C. Ching*, no. 5394, May 26, 1928 (climber 2.5 m.; flowers white, scented) (AA). Kwangtung: Honam Island, *C. O. Levine* no. 910, June 18, 1917 (AA). Fukien: dry place on Ling Pu Mt., vicinity of Foochow, *Tang Siu Ging* (under direction of F. P. Metcalf), no. 5196, Oct. 26, 1926 (AA); Foochow, *H. H. Chung*, no. 3836, Aug. 27, 1925 (shrub 0.70 m. tall; flowers white) (AA).

This species has been so long in cultivation that it is now quite difficult to cite its original spontaneous source with certainty. It is commonly known as the Arabian Jasmine. However, it is so commonly cultivated in China that one feels all the specimens cited are cultivated (even though no mention is made on the label) or escaped from cultivation.

The synonyms of such a popular species are many but the species itself is so distinct that, as a rule, the synonyms can be easily recognized as such. An interesting exception is *Jasminum Blancoi* Hasskarl (Flora, XLVII. 4, 1864) cited by Merrill in Enum. Philipp. Flow. Pl. II. 308 (1923) as a synonym of *J. sambac.* It seems Merrill overlooked the fact that Hasskarl mentions *Nyctanthes Sambac* Blanco, non L., as a synonym to his species. Hasskarl says that the leaves are compound and that there is a relationship between *J. Blancoi* and *J. grandiflorum* L. Blanco in describing *Nyctanthes Sambac* Blanco in Fl. Filip. 9 (1837) calls the leaves compound and mentions three pairs of leaflets. Of course, he had something entirely different from *Jasminum sambac* (L.) Aiton in mind.

This is probably only an oversight on the part of Dr. Merrill because his identified specimens of *J. sambac* from the Philippine Islands accord with *J. sambac* from China and India, as we interpret it, by having simple, opposite leaves.

24. **Jasminum multiflorum** (Burman f.) Andrews, Bot. Repos. VIII. t. 496 (1807).—Heyne apud Roth, Nov. Pl. Sp. 6 (1821).—Merrill, Fl. Manila, 366 (1912); Enum. Philipp. Flow. Pl. III. 307 (1923).

Nyctanthes multiflora Burman f., Fl. Ind. 5. t. 3, f. 1 (1768).

Nyctanthes pubescens Retzius, Obs. v. 9 (1789).

Jasminum pubescens Willdenow, Sp. Pl. I. 37 (1797).—Roxburgh, Fl. Ind. I. 90 (1820).—DeCandolle, Prodr. VIII. 302 (1844).—C. B. Clarke in Hooker f., Fl. Brit. Ind. III. 592 (1882).—Hemsley in Jour. Linn. Soc. XXVI. 80 (1889).—Léveillé in Fedde, Rep. Spec. Nov. XIII. 149 (1914).—Chung in Mem. Sci. Soc. China, I. 216 (1924).

Mogorium pubescens Lamarck, Encycl. Méth. IV. 213 (1797).

Jasminum Esquirolii Léveillé in Fedde Rep. Spec. Nov. X. 147 (1911).—**Syn. nov.**

Kwangsi: Hin Yen, R. C. Ching, no. 6667, August 4, 1928 (AA). Kwantung: Canton, Central Park, *Y. Tsiang*, no. 1574, Nov. 28, 1929 (AA, NY); probably on Canton Christian College Campus, Canton, *G. W. Groff*, Herb. no. 11501, date lacking (C). Kweichow: Hang-Tong, *J. Esquirol*, no. 729, June 1906 (arbrisseau; fleurs blanches) (AA, isotype of *J. Esquirolii*).

In all three treatments of the Chinese Jasminums the authors have treated this species under the name *J. pubescens* Willd. This name was based on a transfer to the genus *Jasminum* of a species named *Nyctanthus pubescens* Retzius described in 1789. However, Burman f. in 1768 (twenty-one years earlier) described *Nyctanthes multiflorum* which is synonymous. Andrews made the transfer of *Nyctanthes multiflora* to *Jasminum multiflorum* in 1807. However, with the exception of Heyne (apud Roth) in 1821 and later Merrill in 1912 and 1923, the synonym *J. pubescens* Willd. was used universally in botanical literature.

Léveillé's *Jasminum Esquirolii* described in 1911 is also a synonym according to the isotype in this herbarium.

25. **Jasminum coarctatum** Roxburgh, Fl. Ind. I. 91 (1820).—DeCandolle, Prodr. VIII. 308 (1844).—Chung in Mem. Sci. Soc. China, I. 216 (1924).

Jasminum reticulatum Wallich, Cat. no. 2869 (1829), nomen.—De Candolle, Prodr. VIII. 303 (1844).

Yunnan: South Road, Szemao, alt. 1525 m., *A. Henry*, nos. 11653 and 11653A (climber with white flowers) (AA, NY); Red River Valley near Manpan, alt. 900 m., *A. Henry*, no. 10887 (shrub 3 m. with white flowers) (AA); near Muang Hun plain, between Muang Hun and Muang Hai, alt. 1290 m., *J. F. Rock*, no. 2416, Feb. 13, 1922 (AA); climber on ridge near Szemao, between Muang Hing and Szemao and the Szemao hills proper, alt. 1650 m., *J. F. Rock*, no. 2763, March 3, 1922 (AA); same locality, *J. F. Rock*, no. 2781, March 9, 1922 (AA). Assam: precise locality lacking, *Colonel F. Jenkins* (G).

26. **Jasminum amplexicaule** Buchanan-Hamilton in Wallich, Cat. no. 2853 (1829), nomen.—G. Don, Gen. Syst. IV. 60 (1837).—DeCandolle, Prodr. VIII. 306 (1844).

Jasminum undulatum Ker-Gawler in Bot. Reg. VI. t. 436 (1820).—Savi, Fl. Ital. III. t. 85 (1824).—C. B. Clarke in Hooker f., Fl. Brit. Ind. III. 592 (1882).—Hemsley in Jour. Linn. Soc. XXVI. 81 (1889).—Léveillé in Fedde, Rep. Spec. Nov. XIII. 149 (1914).—Chung in Mem. Sci. Soc. China, I. 217 (1924).—Non Willd.

Jasminum aristatum Wallich, Cat. no. 2875 (1829), nomen.—DeCandolle, Prodr. VIII. 314 (1844).

Jasminum scandens Griffith, Itin. Notes, 102 (1848).—Non Vahl.

Kwantung: Hainan, *C. Ford*, May 19, 1893 (AA, NY); roadside Hainan, near Kingchow, *F. A. McClure*, 2353, April 5, 1922 (vine 7 m. high, with very fragrant white flowers) (C); Hwa Die, Canton, *Y. Tsiang*, no. 417, May 25, 1928 (AA); in open field on way to Hwang-lung-kwan, Lonfoushan Mts., East River Region, alt. 232 m., *Y. Tsiang*, no. 1615, Dec. 18, 1928 (scandent shrub with white flowers) (AA); in dense mixed woods, Vutzeling, Kochow, alt. 830 m., *Y. Tsiang*, no. 2292, May 14, 1929 (scandent shrub; leaves lustrous green above, lighter below; fruit very young greenish) (AA, NY); in open places, North Gate, Kochow, *Y. Tsiang*, no. 2437, May 23, 1929 (shrub with white flowers) (NY); in open places along side of West Lake, Liuchow, *Y. Tsiang*, no. 2573, June 3, 1929 (scandent shrub with white flowers) (AA, NY); Honan Island, *C. O. Levine*, no. 1209, August 25, 1917 (G); Hoihow, *F. A. McClure*, no. 7618, Oct. 12, 1921 (vine 1–7 meters; flowers white, blue, lavender, very fragrant; fruit black) (AA); Honam Island, *C. O. Levine*, no. 208, Dec. 30 (1916) (AA); precise data lacking, *Mrs. S. W. Williams* (G, NY). British India: Mt. Sylhet, Assam, *N. Wallich*, no. 2853 (AA, photo. of type from Br).

Most of the previously determined material of *J. amplexicaule* Buch.-Ham. has been labeled either *J. undulatum* Willd. or *J. undulatum* Ker-Gawl. Willdenow described the first and original *J. undulatum* in Spec. Pl. which material later was found to be conspecific with *J. sambac* Ait. Ker-Gawler with material distinctly different illustrated and discussed the present species under the name *J. undulatum* thinking it to be the same. Later after the original *J. undulatum* of Willd. had been transferred to *J. sambac* botanists encountering the material illustrated by Ker-Gawler continued calling it *J. undulatum*, accrediting, however, the authorship to Ker-Gawler. Under the present International Rules this latter name is invalidated being a later homonym and it is necessary to accept the name *J. amplexicaule* proposed by Buchanan-Hamilton in 1829, which up to this time has been considered a synonym of Ker-Gawler's species.

26a. Jasminum amplexicaule Buch.-Ham. var. **elegans** (Hemsl.) comb. nov.

Jasminum undulatum Ker var. *elegans* Hemsley in Jour. Linn. Soc. XXVI. 81 (1889).

K w a n t u n g : Pakhoi, *Playfair* (ex Hemsley, l. c.).

Hemsley in the original description of this variety cited material from both Kwantung and Formosa. In the herbarium of the Arnold Arboretum, no material from Kwantung can be found. However, Wilson's nos. 10296 and 11132 and Henry's no. 689 from Formosa all representing this variety are available at the Arnold Arboretum.

LISTS OF COLLECTORS NUMBERS

AITCHISON, J. E. T.
289. J. humile

D'ARGY, CH.
——. J. floridum

BOCK, C. & A. v. ROSTHORN
163. J. floridum
1151. J. floridum

CAVALERIE, J.
3038. J. sinense
3912. J. polyanthum
——. J. Prainii

CHIAO, C. Y.
2583. J. nudiflorum

CHING, R. C.
1890. J. lanceolarium var. puberulum
3313. J. lanceolarium
5175. J. anastomosans
5394. J. sambac
5970. J. lanceolarium var. puberulum
6282. J. lanceolarium
6667. J. multiflorum
6954. J. lanceolarium
7023. J. sinense
7521. J. pentaneurum

CHUN, W. Y.
3088. J. lanceolarium
3468. J. floridum
3572. J. floridum
3845. J. lanceolarium var. puberulum
5670. J. lanceolarium var. puberulum
6344. J. pentaneurum
6911. J. lanceolarium
7470. J. lanceolarium
30472. J. pentaneurum

CHUNG, H. H.
959. J. sinense
3585. J. lanceolarium var. puberulum
3836. J. sambac

CLEMENS. J. & M. S.
3448. J. lanceolarium

DUCLOUX, F.
6. J. Beesianum
58. J. polyanthum
112. J. dumicolum
165. J. Mesnyi
483. J. Beesianum
800. J. polyanthum
7175. J. Mesnyi

ESQUIROL, J.
729. J. multiflorum
887. J. lanceolarium var. puberulum
——. J. polyanthum

FABER, ERNST
47. J. urophyllum

FANG, W. P.
788. J. floridum
2196. J. urophyllum
4239. J. floridum
5666. J. lanceolarium

FORD, C.
113. J. microcalyx
——. J. amplexicaule
——. J. lanceolarium
——. J. lanceolarium
——. J. pentaneurum
——. J. sinense

FORREST, G.
2021. J. Beesianum
4658. J. polyanthum
4659. J. humile
4683. J. officinale f. grandiflorum
5529. J. heterophyllum var. subhumile
7861. J. sinense
7926. J. dumicolum
8072. J. lanceolarium
8094. J. dumicolum
8136. J. urophyllum var. Wilsonii
9346. J. dumicolum

9531. J. dumicolum
9744. J. Mesnyi
9757. J. dumicolum
9761. J. polyanthum
9873. J. heterophyllum var. subhumile
9955. J. Mesnyi
9990. J. heterophyllum var. glabricorymbosum
10066. J. Beesianum
10107. J. officinale
11037. J. heterophyllum var. glabricorymbosum
11177. J. heterophyllum var. glabricorymbosum
11472. J. heterophyllum var. glabricorymbosum
11667. J. Seguinii
11827. J. lanceolarium
13832. J. humile
13834. J. nudiflorum var. pulvinatum
14478. J. nudiflorum var. pulvinatum
15605. J. Seguinii
15720. J. dispermum
16193. J. nudiflorum var. pulvinatum
18330. J. Seguinii
18927. J. humile
19251. J. humile
19296. J. officinale
19666. J. nudiflorum var. pulvinatum
20004. J. nudiflorum var. pulvinatum
20417. J. officinale
23166. J. Seguinii

GAMME, G. A.
——. J. officinale f. grandiflorum

GING, T. S.
5196. J. sambac

GIRALDI, J.
1519. J. Giraldii
——. J. Giraldii

GROFF, G. W.
11501. J. multiflorum

HANDEL-MAZZETTI, H.
20. J. Beesianum
5827. J. coffeinum
8613. J. Mesnyi
10649. J. lanceolarium var. puberulum
11010. J. sinense

HELFER, J. W.
3718. J. officinale f. grandiflorum

HENRY, A.
940. J. lanceolarium
2700. J. floridum
2729. J. lanceolarium var. puberulum
3000. J. lanceolarium var. puberulum
3669. J. lanceolarium var. puberulum
4469. J. sinense
4562. J. lanceolarium var. puberulum
6288. J. floridum
8456. J. anastomosans
9107. J. heterophyllum var. glabricorymbosum
9107A. J. heterophyllum var. glabricorymbosum
9107B. J. heterophyllum var. glabricorymbosum
9319. J. Mesnyi
9319A. J. Mesnyi
9433. J. nintooides
9433A. J. nintooides
9433B. J. nintooides
9581. J. Seguinii
9581B. J. Seguinii
9581C. J. Seguinii
9657. J. sinense
9657A. J. sinense
9657B. J. sinense
10314. J. polyanthum
10314A. J. polyanthum
10314B. J. polyanthum
10634A. J. dumicolum
10887. J. coarctatum
11656. J. polyanthum
11708. J. dumicolum
11653. J. coarctatum
11653A. J. coarctatum
11713. J. lanceolarium
11969. J. anastomosans
12661. J. Seguinii
12661A. J. Seguinii
13354. J. sinense
13397. J. officinale f. grandiflorum
——. J. floridum

HENRY, B. C.
22171. J. microcalyx

HERS, J.
2440. J. Giraldii

HO, H. T.
60041. J. pentaneurum

HOOKER, J. D.
——. J. humile
——. J. dispermum

HOOKER, W. J.
Cat. no. 12246. J. officinale f. grandiflorum

Hu, H. H.
426. J. lanceolarium var. puberulum
1065. J. lanceolarium
Hui, W. T.
202. J. lanceolarium var. puberulum
Inayat,
——. J. officinale f. grandiflorum
Jenkins, Colonel
——. J. coarctatum
Kanjilal, U.
4656. J. dispermum
Katsumatra,
5406. J. anastomosans
Keng, Y. L.
218. J. lanceolarium var. puberulum
Keshavanam,
657. J. officinale f. grandiflorum
King, Dr. G.
220. J. dispermum
——. J. dispermum
Laborde, J.
——. J. sinense
Levine, C. O.
208. J. amplexicaule
910. J. sambac
1209. J. amplexicaule
2016. J. pentaneurum
3107. J. lanceolarium
3180. J. pentaneurum
3320. J. sinense
Levine, C. O. & G. W. Groff
42. J. pentaneurum
163. J. lanceolarium
Limpricht, W.
2006. J. Beesianum
2689. J. Giraldii
Maire, E. E.
108. J. Beesianum
199. J. Mesnyi
245. J. humile
253. J. polyanthum
451. J. humile
3310. J. Beesianum
3352. J. officinale
7188. J. officinale f. grandiflorum
7417. J. Beesianum
——. J. Beesianum
——. J. humile
——. J. humile
McClure, F. A.
2353. J. amplexicaule
7595. J. microcalyx
7618. J. amplexicaule
9193. J. anastomosans
Mell, R.
62. J. lanceolarium
215. J. pentaneurum
922. J. pentaneurum
Merrill, E. D.
10693. J. lanceolarium
Mesny, W.
21211. J. Mesnyi
Meyer, F. N.
1817. J. floridum
Parker, R. N.
2979. J. officinale f. grandiflorum
——. J. dispermum
——. J. humile
——. J. officinale
Prain, Dr. D.
892. J. lanceolarium
Purdom, Wm.
368. J. Giraldii
907. J. Giraldii
908. J. Giraldii
Ram, Bis
124. J. dispermum
147. J. humile
326. J. dispermum
360. J. humile
452. J. officinale
460. J. dispermum
462. J. humile
Rawat, C. S.
76. J. dispermum
Rock, J. F.
2416. J. coarctatum
2440. J. Seguinii
2507. J. anastomosans
2611. J. anastomosans
2763. J. coarctatum
2781. J. coarctatum
2829. J. Mesnyi
2934. J. lanceolarium
3016. J. dispermum
3026. J. heterophyllum var. glabricorymbosum
3069. J. lanceolarium
3190. J. officinale
3216. J. Beesianum
3244. J. officinale
3293. J. humile
3312. J. officinale
3879. J. heterophyllum var. glabricorymbosum
3955. J. heterophyllum var. glabricorymbosum
4509. J. stephanense
6214. J. Seguinii
7833. J. lanceolarium
7894. J. dumicolum

8033. J. heterophyllum var. glabricorymbosum
8292. J. heterophyllum var. glabricorymbosum
8539. J. heterophyllum var. glabricorymbosum
8896. J. nudiflorum var. pulvinatum
10602. J. heterophyllum var. glabricorymbosum
14653. J. humile
14797. J. humile
15035. J. humile

ROYLE, DR. J. F.
——. J. officinale

RUSE, L. F.
135. J. lanceolarium

SCHNEIDER, C. K.
32. J. Mesnyi
486. J. Mesnyi
702. J. officinale
905. J. Beesianum
973. J. Beesianum
1137. J. Seguinii
1302. J. humile
1474. J. officinale
2082. J. Beesianum
2150. J. Seguinii
3199. J. Beesianum
3222. J. humile
3264. J. humile
4091. J. humile

SCHOCH, O.
18. J. polyanthum
36. J. humile
206. J. officinale
207. J. Beesianum

SEGUIN, J.
2354. J. Seguinii

SKATCHKOV, C. A.
——. J. floridum

SMITH, HARRY
1583. J. Mesnyi
1622. J. polyanthum
1886. J. Beesianum
1890. J. humile
2463. J. humile
5508. J. nudiflorum

STEWART, R. R.
2467. J. humile
6228. J. officinale f. grandiflorum

STRACHEY, R. & J. E. WINTERBOTTOM
1. J. humile
2. J. humile
5. J. officinale f. grandiflorum
6. J. dispermum

TAK, TSANG WAI
16718. J. lanceolarium

TÉN, SIMEON
99. J. heterophyllum var. glabricorymbosum
131. J. Seguinii
375. J. humile
499. J. Beesianum
515. J. humile

THOMSON, T.
——. J. dispermum
——. J. humile
——. J. officinale

TO, AH
3177. J. pentaneurum

TSIANG, Y.
417. J. amplexicaule
1143. J. pentaneurum
1490. J. pentaneurum
1574. J. multiflorum
1615. J. amplexicaule
2221. J. anastomosans
2244. J. anastomosans
2244A. J. pentaneurum
2292. J. amplexicaule
2437. J. amplexicaule
2544. J. anastomosans
2573. J. amplexicaule
2970. J. lanceolarium
3005. J. lanceolarium

TSO, C. L.
21001. J. lanceolarium var. puberulum

TSU, L. F.
629. J. floridum

WALLICH, N.
2853. J. amplexicaule

WANG, Y. K.
321. J. pentaneurum
1832. J. pentaneurum
3206. J. lanceolarium
3219. J. lanceolarium

WIGHT, ROBERT
1752. J. officinale f. grandiflorum

WILSON E. H. (ARNOLD ARBORETUM EXPED.)
598. J. Giraldii
781. J. lanceolarium
781A. J. lanceolarium var. puberulum
789 in part. J. floridum
1122. J. urophyllum
2807. J. officinale
2808. J. sinense
2809. J. humile
——. J. humile

WILSON, E. H. (VEITCH EXPED.)
83. J. floridum
1018. J. lanceolarium var. puberulum
1499. J. urophyllum var. Wilsonii
1576. J. sinense
4074. J. Beesianum
4074A. J. officinale
4075. J. urophyllum var. Wilsonii

HERBARIUM, ARNOLD ARBORETUM, HARVARD UNIVERSITY.

4077. J. humile
4078. J. humile
5042. J. lanceolarium

WILLIAMS, MRS. S. W.
——. J. amplexicaule

WRIGHT, C.
——. J. lanceolarium

ZIMMERMANN, R.
296. J. nudiflorum

THE CYTOLOGICAL MECHANISM OF CROSSING OVER

KARL SAX

With plate 44, one text figure and 11 diagrams

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INTRODUCTION

Two theories concerning the mechanism of crossing over have recently been advanced. The first theory is essentially the "partial chiasmatypy" hypothesis of Janssen's (1924), which is based on the assumption that chiasmata are caused by crossing over between two of the four chromatids. This theory has been sponsored by Belling (1929, 1931, a. b.), Darlington (1930, 1931) and Maeda (1930). The other theory of crossing over is based on the assumption that chiasmata do not represent crossovers, but are caused by an alternate opening out of sister and non-sister chromatids at diplotene (Weinrich 1916; Robertson 1916; Wilson 1925; Seiler 1926; McClung 1927; Belar 1928). A crossover occurs only when two chromatids break at a chiasma (Sax 1930).

An analysis of chromosome behavior at meiosis and an analysis of crossover types in the attached X chromosomes in *Drosophila melanogaster* should afford some critical evidence for a comparison of the two theories of the cytological mechanism of crossing over. This work is based on a cytological study of the chromosomes of *Callisia repens*, a survey of chiasma frequency in other plant genera, and an analysis of some of the genetic evidence obtained from *Drosophila*.

CHROMOSOME BEHAVIOR IN CALLISIA REPENS

In *Callisia repens* it is possible to follow the behavior of the chromosomes at all stages from pachytene to metaphase. This

material was collected and preparations made at the Harvard Botanic Garden, Soledad, Cuba. The writer is indebted to Professor Oakes Ames, Supervisor of the Arnold Arboretum and the Harvard Botanic Garden, for making possible the trip to Cuba.

Callisia repens has six pairs of large chromosomes. In two pairs of chromosomes the spindle fiber attachment points are more or less median while the other four pairs have nearly terminal fiber attachments. The twelve somatic chromosomes are shown in text-figure 1. The chromosome in the middle of the metaphase plate has one

FIG. 1. CHROMOSOMES OF CALLISIA REPENS

arm oriented at right angles to the plane of the other chromosomes. The sister chromatids in many of the chromosomes are clearly separated and show little twisting about each other. The limited number of twists or half twists in the somatic chromosomes is of special interest in connection with the theories of crossing over.

The study of meiotic chromosomes is based on smear preparations of pollen mother cells fixed in Navaschin's solution and stained with crystal violet iodine. The figures in the plate were drawn at a magnification of 3100 diameters and reduced about one-fourth in reproduction.

During the early pachytene stage the spireme is so compact that individual chromosomes cannot be identified. A small nucleolus is always present and is almost invariably at the periphery of the spireme and in contact with a free end of a chromosome thread. As the spireme opens up it is evident that it consists of six long interlooped chromosomes (Plate 44, fig. 1). The end of one of the shorter chromosomes is invariably in contact with the nucleolus. At a somewhat later stage the six bivalent chromosomes, still paired throughout their length, can be easily recognized. This stage is shown in figure 2. The two long bivalents are numbered 2 and 5. One of the short chromosomes, number 3, appears to have started

opening out into the typical nodes and internodes of the diplotene stage. The nodes and internodes at this stage appear to be much more numerous than at late diplotene.

The chromosomes shown in figure 3 have in most cases opened out into the diplotene loops, although parts of several chromosomes appear to have remained closely paired as they were at the typical pachytene stage. The nucleolus shows considerable disintegration at this stage and usually the side away from the chromosome attachment disappears first. The nucleolus is attached to one of the shorter chromosomes in all cases and it seems very probable that the same chromosome is always associated with the nucleolus.

When all of the chromosomes have reached the diplotene stage the number of nodes per chromosome ranged from two to more than five. It is not possible to recognize the individual chromatids in this material so that it is impossible to be sure that all of the nodes are chiasmata, but judging from the association of chromatids in *Orthoptera* chromosomes and at later stages in plant species it seems probable that most of them are chiasmata. The total number of nodes or chiasmata at diplotene is about twenty-five or an average of somewhat more than four per bivalent (Fig. 4.)

At early diakinesis the chromosomes become much thicker and shorter. An intermediate stage is shown in figure 5. The number of nodes or chiasmata is reduced to a total of about ten. The two long chromosomes seem to show some evidence of fiber constriction points but for the most part these constrictions do not show. Later stages of diakinesis are shown in figures 6 and 7. The total number of nodes is now at a minimum and no further reduction takes place before the chromosomes are separated at the first meiotic division.

The individual chromatids are not distinguishable even at the first metaphase but the configuration of the bivalents shows the number of attachment points. The chromonemata are distinctly coiled in some cases, but are not sufficiently clear for a critical study of the association of chromatids (Fig. 8). At telophase two of the daughter chromosomes have four arms since the fiber attachment is more or less median, while the other four daughter chromosomes consist of the two sister chromatids attached at one end by the fiber constriction (Fig. 9). The nucleolus disappears at metaphase.

The constant association of the nucleolus with one of the shorter chromosomes enables this particular chromosome to be recognized at all stages up to metaphase. This chromosome at late pachytene is shown at the left in figure 10 to show the relative amount of contraction which occurs between pachytene and late diakinesis. The

decrease in length is somewhat more than one-half. Five of the marked chromosomes are shown at the diplotene stage (Fig. 10) for comparison with the same chromosomes at diakinesis (Fig. 11—the five chromosomes to the right). An intermediate stage is also included at the left. It is apparent that there is considerable reduction in the number of nodes, most of which are presumably chiasmata, between diplotene and diakinesis. In the five diplotene chromosomes the average number of nodes is about three per chromosome, while at diakinesis it is only a little more than one per bivalent. An examination of 26 of these marked chromosomes at diplotene showed an average of 2.1 nodes per bivalent while 28 bivalents at diakinesis had an average of 1.1 nodes or chiasmata. For these short chromosomes the reduction of nodes is about 1 per bivalent, or one-half of the nodes formed at diplotene. The long chromosomes may have as many as four or five nodes at diplotene but seldom more than two at diakinesis.

While this evidence is not conclusive it does indicate that there is considerable reduction in the number of chiasmata between early diplotene and the first meiotic metaphase stage.

THE BEHAVIOR OF THE NUCLEOLUS

At the earliest prophase stages of meiosis in *Callisia* only one nucleous is observed. The nucleolus is almost invariably at the periphery of the spireme and attached to the end of a spireme thread. As soon as the spireme is opened up enough to follow the threads it is found that no continuous spireme exists. There are six distinct chromosomes at this stage and the nucleolus is attached to one of these chromosomes, and later stages show that the same chromosome is always involved. As the chromosomes contract the nucleolus disintegrates and it finally disappears at metaphase.

It is apparent that the nucleolar contents cannot pass into the entire spireme thread. It is doubtful if the spireme thread is ever continuous in either the somatic or meiotic prophases of *Callisia*. The fact that the nucleolus disappears or decreases in size and staining capacity as the chromosomes develop has led to the belief that the nucleolar material is absorbed by the chromosomes. A review of the work on nucleolar activity has recently been presented by Zirkle (1931) and by Fikry (1930).

Fikry has presented what appears to be a logical explanation of the relation between nucleoli and chromosomes, and this interpretation seems to have considerable cytological support. The gene string builds up a surrounding sheath of chromatin as the chromosomes develop from early prophase. Each gene builds up its own

specific enzyme complex. At telophase this chromatic product is released from the gene strings, or chromatids, to form the nucleolus. In the next division the nucleolar substance passes out into the cytoplasm carrying with it the specific gene enzymes or enzyme products.

Certainly this theory offers an attractive hypothesis to account for the transmission of gene activity to the cytoplasm. The genes develop a chromatin sheath which is later differentiated into the more chromatic chromonemata and the more or less diffuse chromatin or oxychromatin. As the chromosomes pass to the poles at telophase the chromosome sheaths or pellicles fuse to form the nuclear membrane and the more fluid chromatin matrix is released to form nucleoli (Bridges in Alexander 1928). In cases where the chromosomes are not closely associated at telophase, as in the gymnosperms, many nucleoli are formed, but in most angiosperms the chromosomes are compact at telophase and the released oxychromatin fuses to form one or two nucleoli. The nucleoli become still further transformed so that they no longer take the typical chromatin stains (Zirkle 1931). As the chromosomes develop for the next division the nucleolus usually disintegrates and when the nuclear wall breaks down the products of the nucleolus become incorporated in the cytoplasm. Occasionally the nucleolus persists until metaphase where it may pass to one pole, or divide and pass to both poles, but in either case it usually passes into the cytoplasm and is absorbed. (Yamaha and Sinoto 1925.)

THE MECHANISM OF CROSSING OVER

A modification of Janssen's (1924) "partial chiasmatypy" theory of crossing over has recently been sponsored by Darlington (1930), Maeda (1930) and Belling (1931, a. b.). This theory postulates that a chiasma is caused by crossing over between two of the four chro-

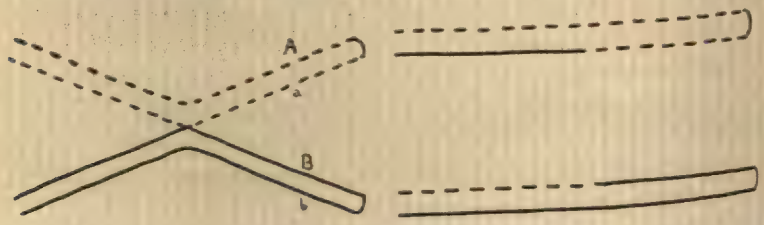


DIAGRAM 1

matids at pachytene. At diplotene the chiasmata represent crossovers and only sister chromatids are paired as shown in diagram 1. When the homologues are separated at metaphase the crossover at

the chiasma will result in two non-crossover chromatids and two crossover chromatids. Every chiasma represents a crossover, but according to Maeda and Belling every point of contact or node at diplotene is not necessarily a chiasma, but may be an overlap or temporary fusion of the paired chromatids. The assumptions upon which this theory is based have been criticized by McClung (1927). The more recent arguments of Belling and Darlington will be considered later in this paper.

In 1930 the writer presented an hypothesis to account for the mechanism of crossing over which seems to have considerable cytological support and is in accord with the genetic requirements. This theory is based on the usual assumption that chiasmata are formed by the alternate opening out of sister and non-sister chromatids at diplotene. A crossover is caused by a break in the two crossed chromatids at a chiasma between diplotene and late diakinesis. (Diagram 2.)

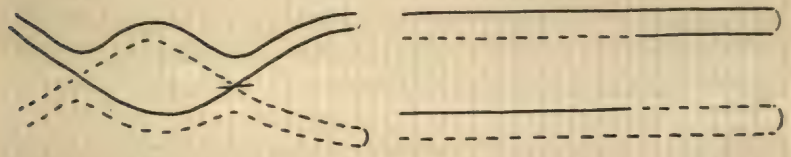


DIAGRAM 2

It is assumed that sister chromatids are alway's associated at the spindle fiber attachments during the first meiotic civision, which is in accord with both the cytological and genetic evidence. The second meiotic division separates the sister chromatids and is an equational division for regions of the chromosome between the spindle fiber and the first crossover.

The paired chromatids are assumed to be associated, gene by gene, throughout their length, so that a crossover usually occurs between the same two consecutive genes in each chromatid as shown in diagram 3. The spindle fiber is to the right and is terminal.

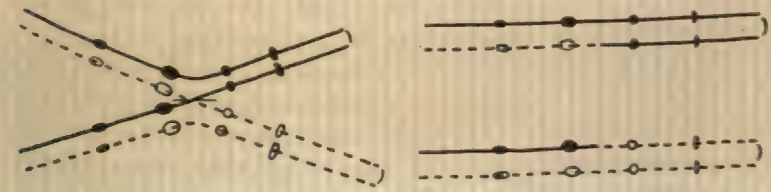


DIAGRAM 3

In rare cases unequal crossing over occurs (Sturtevant 1925, 1928, Morgan 1931) which can be accounted for if the genes in the region

of the chiasma are not closely paired. In such a case crossing over need not occur between the same two consecutive genes in each chromatid, but may result in gene duplication and deficiency as shown in diagram 4.

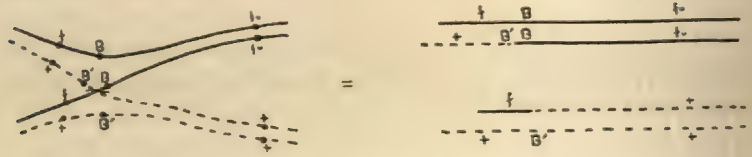


DIAGRAM 4

Gene duplication and deficiency occur in case of the bar gene in the X chromosome of *Drosophila* only when there is crossing over between forked and fused, so Sturtevant concluded that crossing over does not occur between sister chromatids in this region of the X chromosome. The order of the two duplicated genes bar and infrabar may be BB′ or B′B. In diagram 4 the order of these genes is BB′ but if the chromatids cross and break above these two genes the order will be B′B. All of these genetic observations can readily be explained on the writer's hypothesis.

Crossing over between sister chromatids, according to this theory, cannot occur before the first regular genetically detectable crossover, and at other points can occur only when a half twist occurs in one pair of sister chromatids accompanied by an opening out of non-sister pairs of chromatids on both sides of the half twist. (Diagram 5.)

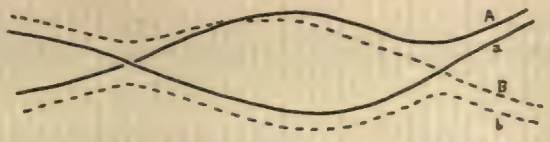


DIAGRAM 5

The first crossover from the spindle fiber end of the chromosome would invariably occur between non-sister chromatids, but in some cases subsequent crossovers might occur between sister threads. Thus there would be little chance for a sister thread crossover to occur at the bar locus in the X chromosome of *Drosophila* because bar is only about 12 units from the fiber attachment point. The hypothesis is again in accord with the genetic observation that crossing over does not occur between sister chromatids at the bar locus (Sturtevant 1928).

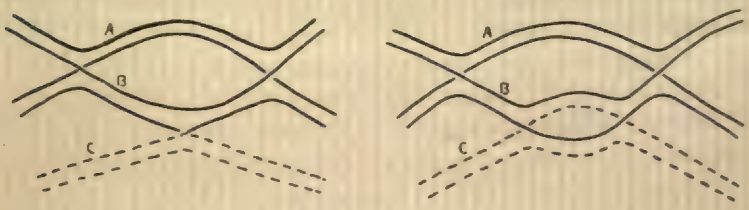
Factors which suppress crossing over in *Drosophila* (Gowen 1922, 1928) also inhibit chromosome pairing. Crossover reducers are known to be caused by inverted segments (Sturtevant 1926) trans-

locations (Dobzhansky 1931) and may be caused by deficiencies. Any factor which inhibits chromosome pairing would of course decrease or eliminate crossing over between homologous chromosomes on either theory of crossing over.

JANSSEN'S "PARTIAL CHIASMATYPY" HYPOTHESIS

According to Darlington (1930) "partial chiasmatypy," which demands crossing over between two of the four chromatids at every chiasma, is the only possible working hypothesis for the correlation of the cytological and genetical observations." Darlington's argument is based on the types of chromosome association in triploids and tetraploids. The drawings and diagrams in his 1930 paper "are the result of a special search for the missing configuration in this critical material." In *Tulipa* and *Hyacinthus* triploid chromosomes were occasionally found to be associated as shown in diagram 6. A third chromosome intercalated between two chiasmata of a bivalent by a single chiasma is assumed to be critical evidence that this chiasma is caused by a previous crossover between two chromatids. If a third chromosome in triploids is invariably intercalated between two chiasmata in the other two chromosomes by a single chiasma there might be some justification for Darlington's conclusion, but since the frequency of such types is not known, the evidence presented is not critical.

These types of trivalents can also be explained on the assumption that chiasmata are caused by alternate opening out of sister and non-sister chromatids and that one chiasma disappears before diakinesis due to breaks in the chromatids as shown in diagram 7.



DIAGRAMS 6 AND 7

According to this theory of chiasma formation chromosome C must form two chiasmata with chromosome B. But if one of these chiasmata frequently breaks, as would be expected according to the writer's theory of crossing over, then at diakinesis chromosome C will often be associated with B only by a single chiasma. Darlington's tetraploid configurations and *Oenothera* figure 8 chromosomes (Darlington 1931 B) can be interpreted in the same way, and cannot

be considered as critical evidence in favor of Janssen's partial chiasmatypy theory of crossing over.

If all three homologous chromosomes in triploids can pair simultaneously at the same locus, as Belling has described in *Hyacinthus*, then Darlington's "critical" figures could be obtained without any crossing over.

In a later paper Darlington (1931a) attempts to correlate the frequency of chiasma formation with the percentage of crossing over in *Primula sinensis*. The SBGL chromosome, which is assumed to be one of the longest chromosomes of *Primula sinensis*, was estimated from crossover data, to be 111.6 genetic units long, but this may be incorrect since Haldane's (1919) correction of map distance is not valid (Morgan, Bridges and Sturtevant 1925).

According to Darlington's theory of crossing over each chiasma will result in 50 per cent crossing over and the length of a chromosome in genetic units can be calculated as 50 × the number of chiasmata. Darlington finds an average of 3.5 chiasmata per bivalent which he considers may be an under-estimate for the longest chromosomes. Due to an error, Darlington calculated the crossover length, based on number of chiasmata, as 58.3 to 116.7 units, which he says is "in strict agreement with expectation." But the correct length based on chiasma frequency, should be 3.5 × 50 or 175 units as an average, or to range from 116.7 to 233.4 units, as Darlington later discovered. Obviously the length of the longest chromosome as measured by crossing over is only about half as long as the length expected, if each chiasma represents a crossover.

On the writer's theory of crossing over, chromosome SBGL should be somewhat more than 100 units long which is "in strict agreement with expectation"! It is probable however, that neither the genetic nor the cytological data are adequate for any serious calculation of the crossover length of any of the chromosomes in *Primula*.

In order to explain the absence of crossing over in the *Drosophila* male, Darlington (1931 a) assumes that there are always two chiasmata in each bivalent, that the two chiasmata are very close together, that no mutations occur in the region between chiasmata, that the spindle fiber attachment point is between the chiasmata, and that the double crossover invariably involves the same two chromatids. All of these assumptions are highly improbable, and the assumption that the two crossovers are always reciprocal is not in accord with the genetic evidence.

On the alternative theory of crossing over, it is assumed that in the *Drosophila* male, chiasmata are formed as they are in the female, although perhaps less frequently, and that chromosome develop-

ment from diplotene to metaphase is sufficiently gradual so that the chromatids can adapt themselves to the changes without breaking. A gradual development would permit the chromatids to contract as the chromosomes contract so that no coiling of the chromonemata would occur. The chiasmata would be free to terminalize without breaks in the chromatids, as seems to be the case in the Orthopteran chromosomes. Since terminalization is easily effected the meiotic metaphase in the male should be of short duration as compared with the same stage in the female, as seems to be the case (Huettner 1930). The reverse would be the case according to Darlington's theory. Crossing over in the female is most frequent towards the ends of the second and third chromosomes of *Drosophila melanogaster* so that only two subterminal chiasmata would usually need to be pulled apart, but in the male the two reciprocal chiasmata near the spindle fiber would have to be terminalized for practically the entire length of the chromosomes.

Darlington does not attempt to explain why breaks occur in the chromatids at pachytene, why the breaks in the crossover chromatids almost invariably occur at the same level, why chromatids should recombine in new association after they break, why only two chromatids cross over at any one locus, or why one crossover interferes with the occurrence of a second one in the same region.

According to Darlington, at least one chiasma is essential for pairing of homologous chromosomes and every chiasma represents a crossover. Therefore, crossing over must be universal in all normal species and no normal chromosome can be less than 50 genetic units long. No explanation has been presented to account for the behavior of the fourth chromosome of *Drosophila melanogaster*. This chromosome is about as regular in conjugation and disjunction as the X chromosome, but no crossing over occurs in the fourth chromosome. There are also other obvious objections to Darlington's theory of chromosome pairing (O'Mara, in press).

BELLING'S THEORY OF CROSSING OVER

Belling (1931 a) has recently presented an hypothesis to account for the mechanism of crossing over. The homologous chromosomes pair as single chromatids. Half twists occur in the paired homologues at early pachytene before the secondary split has begun. When the secondary split occurs the new chromomeres must form new connecting fibers and at each twist they take the shortest route in connecting adjacent chromomeres. Thus crossing over would occur only between the two new chromatids formed at late pachytene. This interpretation is obviously invalid because in *Drosophila*

crossing over is found in more than 50 per cent of the emerging X chromosomes, and nearly 75 per cent of the third chromosomes have one or more crossovers (Redfield 1930).

More recently Belling's (1931 b) modified his hypothesis. This new theory seems to be plausible since it accounts for crossing over between any two chromatids, and provides a mechanism to explain translocations and inversions in somatic chromosomes. If Janssen's partial chiasmatypy theory of crossing over is correct Belling's hypothesis of the mechanism involved would seem to be the only logical explanation. Unfortunately there are a number of serious objections to this theory.

According to Belling a half twist between single chromatids occurs at pachytene. When the new chromomeres are produced at the secondary split the connecting fiber between genes may remain with the old gene (genes and chromomeres are assumed to be synonymous) according to the laws of chance. The new connecting fibers then unite the free genes by the shortest path (Diagram 8).

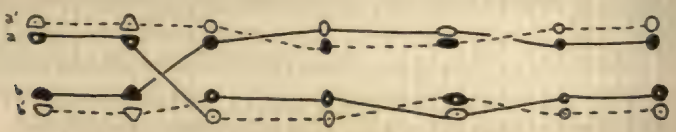


DIAGRAM 8

As shown in the diagram 8, the new connecting fibers may result in a crossover between a′ and b′ or between a′ and b. If the connecting fibers remain with the old genes or pass to the new ones at random there will be random crossing over between any two of the four chromatids.

Random assortment of connecting fibers would also mean that in both somatic and meiotic chromosomes crossing over between sister threads would be very frequent. In a chromosome containing a hundred genes 50 sister crossovers would be expected. In the somatic chromosomes this sister crossing over would result in much twisting of the two chromatids at late prophase and at metaphase, if the new connecting fibers which unite old and new genes pass at random on either side of the old connecting fiber. But there are only a limited number of twists or half twists in the somatic chromosomes (text figure 1) and between paired chromatids at meiosis (Seiler, 1926).

Belling's theory is also based on the assumption that the homologous chromosomes first pair as single chromatids at meiosis. The work of Kaufmann (1926) and Sharp (1929) seems to show that the

somatic chromosomes in certain plant species are already split into two chromatids at the preceding anaphase. According to Kaufmann (1931) the chromosomes at the telophase of the last premeiotic division show the parallel chromonemata. In *Paratettix*, the chromosomes are split longitudinally when they enter the spermatid (Robertson, 1931 a), and Robertson (1931 b), also shows that the homologous chromosomes in the *Tettigidae* are already divided into sister chromatids when they begin pairing at meiosis. Similar observations have previously been made by Robertson (1916) and McClung (1928). These observations cannot be reconciled either with Belling's theory of crossing over, or with Darlington's (1931) theory of meiosis.

One other point in comparing the two theories has been presented by Belling (1931 b) in connection with the behavior of unequal homologues. One pair of unequal homologues were found in *Aloe purpurascens*. If chiasmata are formed by the alternate opening out of sister and non-sister pairs of chromatids, in some cases a short arm should be associated with a long one at diplotene or diakinesis, but no such association was found. On Belling's hypothesis no pairing of long and short arms would be expected since only sister chromatids are paired at diplotene. If the chiasma is to the distal side of the fiber constriction, as shown in diagram 9b, then a short and a long arm should be associated on the writer's hypothesis, unless a crossover had occurred. On Belling's hypothesis such a chiasma (9a) should invariably result in a distribution of a long and a short chromosome to each pole at the first meiotic division, but Belling observes that "in some cases they are observed to separate into short plus long and short plus long chromatids."

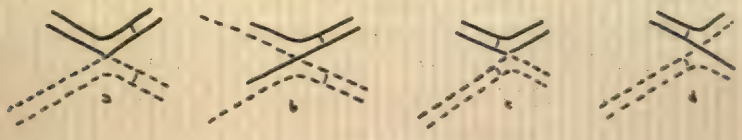


DIAGRAM 9

If, in most cases, the segregation at anaphase is into two short and two long homologues, as Belling's statement would imply, then the chiasma must be to the right of the fiber attachment point (9c) or the homologues are terminally associated without chiasma formation. On the writer's hypothesis a chiasma to the right of the fiber constriction (9b) or a terminal association of chromosomes, would result in the observed association of chromatids—short with short and long with long at diplotene. It is evident that Belling's obser-

vations are inadequate for any critical test of the method of chiasma formation.

REDUCTION IN NUMBER OF CHIASMATA

The writer's theory of crossing over postulates breaks in the chiasmata so that a decrease in the number of chiasmata would be expected between early diplotene and metaphase if crossing over occurs.

At early diplotene, as the homologous chromonemata open out, the nodes and internodes are often very numerous. This condition is indicated in chromosome number 3 in figure 2, and is clearly shown in *Lathyrus* (Maeda, 1930, Fig. 17 B) and in *Zea* (Cooper and Brink 1931, Fig. 1). These nodes may be chiasmata, most of which subsequently meet as the homologous chromonemata open out more completely at the internodes. There is also a possibility that some of these nodes which disappear are due to breaks in chiasmata at this stage of meiosis. Since the individual chromatids cannot be identified many of these early nodes may be only temporary adhesions as Belling has suggested.

In *Tulipa* Newton (1926) pictures about 30 chiasmata in 11 diplotene chromosomes (Fig. 25). At early diakinesis the number of chiasmata are especially clear, and show a total of about 27 chiasmata for the 12 chromosomes (Fig. 31) while at late diakinesis Newton found only 15 chiasmata (Fig. 30). Thus the average number of nodes or chiasmata per bivalent chromosome is reduced from almost 3 at diplotene to only 1.25 at late diakinesis.

In *Lilium longiflorum*, Belling (1928) found a decrease in number of nodes between diplotene and late diakinesis of 43 per cent and suggests that more nodes would have been found if counts could have have been made at an earlier stage. Belling states that "the nodes which disappear between diplotene and late diakinesis do not seem to be all or mainly twists."

In a later paper Belling (1931) concludes that in the same species of *Lilium* the number of nodes is reduced from 42.5 at diplotene to about 30 at late diakinesis and metaphase, and suggests that the nodes which disappear are half-twists or temporary adhesions rather than chiasmata.

Darlington (1931 a) finds an average of 3.5 chiasmata at diplotene in *Primula sinensis* but only 1.89 chiasmata at metaphase. The bivalents at metaphase are associated only by terminal chiasmata. This decrease in number of chiasmata is attributed to terminalization.

Secale chromosomes at diplotene may often have four or five nodes, but never more than two at diakinesis and metaphase (Sax 1930).

In *Rosa blanda*, Erlanson (1931) obtains an average of 1.94 chiasmata per bivalent at early diakinesis, but only 1.31 at metaphase. Doubtless a greater number of chiasmata would have been found at diplotene.

In *Matthiola* Philp and Huskins (1931) found that the average chiasma frequency was 2.26 per chromosome at early diakinesis and only 1.54 at metaphase.

The counts of chiasma frequency at different stages of meiosis are summarized in Table 1. The estimated average crossover length of the chromosomes is calculated from the number of chiasmata which disappear between diplotene and metaphase on the basis of the writer's hypothesis. Since Belling considers that the chiasmata found at metaphase constitute all or most of the true chiasmata formed, the crossover length is also calculated on this basis. Darlington considers the nodes found at diplotene in *Primula* as chiasmata and attributes the loss of chiasmata to terminalization, so crossover lengths are also calculated on diplotene and early diakinesis counts.

TABLE 1

	Ave. no. xta. per bivalent			Estimated Ave. c.o. length		
Genus	Diplotene or early diakinesis	Metaphase	No. lost	S.	B.	D.
Tulipa	2.8	1.3	1.5	75	65	140
Lilium	3.5	2.5	1.0	50	125	175
Secale	3.5	1.8	1.7	85	90	175
Primula	3.5	1.9	1.6	80	95	175
Rosa	1.9	1.3	.6	30	65	95
Matthiola	2.3	1.5	.8	40	75	115
Callisia	4.2	1.5	2.7	135	75	210

Counts of chiasma frequency at early diakinesis do not represent the number formed at early diplotene so that in most of the genera listed above, the number of chiasmata lost should be increased considerably and consequently the crossover length would be increased on the writer's and on Darlington's hypotheses. Little is known concerning the crossover lengths of the chromosomes of the species listed above, but the calculated lengths are comparable to those found in *Drosophila* and *Zea*. Two of the autosomes in *Drosophila melanogaster* are somewhat more than 100 units long and in *Zea* the 5 chromosomes containing the most mutations range from about 50 to 68 units long (Lindstrom 1931). The chiasma frequency in *Zea* chromosomes is about 1.5 at metaphase (Randolph), but data on earlier stages are very meagre although Fisk (1927, Fig. 32) pictures two bivalents with about 5 nodes each. The genetic and cytological work on *Zea* should soon provide adequate data for a critical comparison of chromosome behavior and crossover frequency.

Darlington assumes that the reduction in number of chiasmata is due to terminalization. But as Belling (1931 b) points out, the coiling of the chromonemata would prevent any appreciable movement of the chiasmata after diakinesis. No coiled chromonemata have been described by Darlington, probably due to inadequate fixation or staining for showing this structure, rather than the absence of coiled chromonemata in the species studied. Coiled chromonemata have been described in many species and recently Shinke (1930) has described such chromosome structure in about 25 different genera. The coiling of the chromonemata probably begins at late diplotene so that no extensive movement of the chiasmata can occur, in most cases, between diplotene and metaphase. If it is assumed that the chiasmata are terminalized one might expect that all of them would frequently terminalize before metaphase and produce univalent chromosomes. In *Primula*, and in the *Solanaceae*, the bivalents at metaphase are usually associated only at the two ends forming the typical ring shaped bivalent. Darlington assumes that an average of about 1.5 chiasmata pass off the ends of the *Primula* bivalents. But why should the remaining two chiasmata always stop at the ends of the bivalent?

If each chiasma represents a crossover then the M chromosome of *Vicia faba* must be more than 400 crossover units long. Maeda (1930) finds an average of 8.1 chiasmata in this chromosome, and the number may be as high as 13 in some cases. On any theory of crossing over a twist must occur in the chromatids either at the chiasma or at an internode for every crossover. If one or more crossovers occur there should often be some interlocking of homologues at anaphase as seems to be the case in *Lilium* and *Lathyrus* (Maeda 1930, Sax 1930). With 8 crossovers one might expect considerable difficulty in separating homologues at the first meiotic division. If the chiasmata are not the result of crossovers there would of course be no difficulty in the division of homologues. (McClung 1927).

NON-DISJUNCTION AND CROSSING OVER.

Non-disjunction in *Drosophila melanogaster* was first described by Bridges in 1916. Primary non-disjunction is caused by the production of "2-X" and "no-X" eggs which when combined with normal sperm produce male and female exceptions. These primary exceptions occur with a frequency of about 1 in 2000. Male exceptions are usually produced from 4 to 8 times as frequently as female exceptions (Bridges 1916, Safir 1920, Mavor 1924, Anderson 1931). The excess of male exceptions, which are produced from

"no-X" eggs, is attributed to the failure of the XXs to pass to either pole at the first reduction division.

In normal stocks of *Drosophila* little if any crossing over takes place between the two X chromosomes which pass to the same egg. (Bridges 1916.) In high non-disjunction lines, crossing over is greatly reduced in both the normal and in the exceptional progeny (Morgan et al. 1925). In Anderson's (1929) high non-disjunction stock crossing over between scute and forked was reduced from 62 per cent to 20.9 per cent, and in the XXs which produced exceptional females the crossing over was only 7.3 per cent. Crossing over was almost eliminated in the region of vermillion, 40 units from the left end of the X, but increased towards the ends and was almost normal at the left end. Dr. Anderson informs me that the reduction in crossing over was caused by a translocation involving the X and the third chromosome. Dobzhansky (1932) also finds that translocations reduce crossing over and that non-disjunction is positively correlated with the length of the autosome attached to the Y. Due to the attraction of different chromosome segments chromosome pairing is often weak and crossing over is reduced.

In Anderson's (1931) primary exceptions produced by X-rays the total crossing over between scute and forked was about 60 per cent of the normal, but crossing over was found in all regions, and in two of the regions studied crossing over was almost normal. About 14 per cent of the XXs were homozygous for the forked locus where less than 5 per cent would be expected. This excess of homozygosis at forked is attributed to non-disjunction at the second maturation division, the only logical explanation of the results obtained. In view of the great irregularity of crossing over in different regions compared with the control it seems possible that there was 6 per cent of crossing over to the right of forked. At any rate crossing over between the XXs which pass to the same egg, is not confined to the distal ends of the chromosomes and some crossing over occurs to the right of forked.

If non-disjunction is due to a failure of XXs to separate at the first maturation division it is rather difficult to account for the decrease in crossing over in high non-disjunction stock if chiasmata represent crossovers. According to Darlington (1931) chiasmata form the only bonds between homologous chromosomes and if no chiasmata are formed the chromosomes would not be expected to form bivalents at meiosis. Failure of the XXs to disjoin would then be attributed to more than the usual number of chiasmata, but an excess of chiasmata would also mean an excess of crossing over on either Belling's or Darlington's interpretation. On the writer's

interpretation the decreased amount of crossing over in high non-disjunction lines could be attributed to few breaks at chiasmata so that the homologues would be united by more than the usual number of chiasmata and could not separate so readily.

There is good evidence, however, that non-disjunction is really a failure of chromosome pairing at the later stages of the first meiotic divisions. The decreased crossing over in high non-disjunction strains of *Drosophila*, and in the XXs which pass to the same egg in normal stock, can be attributed to non-conjugation or to pairing in only restricted regions of the chromosome. If only a few chiasmata are formed, due to incomplete pairing, then crossing over would be reduced on either theory of crossing over. The premature separation of homologues could be attributed to either early terminalization of these few chiasmata, or to breaks which would result in cross-overs. On Darlington's and Belling's theory, all of the chiasmata must be prematurely terminalized. The failure of chiasma formation, or breaks the few chismata formed, would produce unpaired homologues at the first maturation division. If these univalents pass at random to either pole, then half of the eggs should contain no X or 2 X chromosomes, and half should contain the usual 1 X. The univalents often fail to reach the poles in species hybrids and in haploids, and are often lost in the cytoplasm. If then one of the two X chromosomes should be lost there will be an excess of no-X eggs which produce the male exceptions. Such a behavior of the univalents would account for the excess of male as compared with female exceptions. This explanation of non-disjunction seems to be more plausible than the assumption that the two XXs are so intimately paired that they fail to divide and both pass to the same pole or fail to reach either pole.

If non-disjunction is due to a failure of the X chromosomes to separate it is difficult to account for the decrease in crossing over in high non-disjunction lines of *Drosophila* on the theories of crossing over proposed by Belling and by Darlington. On the other hand if non-disjunction is due to non-conjugation at metaphase, as seems probable, then all chiasmata must be broken or prematurely terminalized. If chiasmata are crossovers then all of the XX chromosomes which show crossing over must have separated prematurely by complete terminalization and elimination of all chiasmata. In the high non-disjunction stock of Anderson's about 7 per cent of the crossovers between the two XXs which pass to the same egg occur to the right of forked, and in the X-ray material 6 per cent of the crossovers may have occurred to the right of forked. In most of these forked equationals an additional crossover also occur-

to the left of forked. If crossovers produce chiasmata then in these chromosomes there are usually two chiasmata which must be terminalized to produce "non-disjunction" and one of the chiasmata is to the right of forked so that it would have to be prematurely terminalized for practically the entire crossover length of the chromosome. If such terminalization is possible it would seem that non-disjunction should be frequent, but primary exceptions occur with a frequency of about one in 2000, in normal stocks of *Drosophila*, and in only 2.5 per cent of the progeny from high non-disjunction lines. The cytological evidence also indicates that extensive terminalization or movement of chiasmata is improbable (Belling 1931 b).

If Painter's (1931) cytological map of the X chromosome is correct there is some possibility that premature terminalization could occur because the region from scute to forked constitutes only about a third of the cytological length of the X chromosome. Stern (1931) working with the same stock finds that the region from scute to forked constitutes about one-half of the X chromosome and his figures clearly support this interpretation. It would seem improbable that two chiasmata could be prematurely terminalized, one for more than half the length of the X chromosome. Even in species where the homologous chromosomes are always associated by only terminal chiasmata at metaphase there is little or no tendency for premature separation of the chromosomes.

On the writer's theory of crossing over it is not difficult to explain "non-disjunction" even where crossing over occurs near the spindle fiber end of the X chromosome. If few chiasmata are formed at diplotene and all of them break in certain bivalents, then these chromosomes will be loosely associated so that precocious disjunction before metaphase would be possible.

There are, however, certain types of double crossovers that are difficult to explain unless some terminalization of chiasmata occurs. In Anderson's high non-disjunction data there is 1 and in the X-ray data there are 4 double crossovers of the type $\frac{aab}{aba}$ or $\frac{bba}{bab}$. These reciprocal-equational double crossovers can only occur, on the writer's hypothesis, if there is an unbroken chiasma between sister chromatids between the first and second genetically detectable crossovers, or a twist in the sister chromatids between the second and third crossovers. In Anderson's (1931) table 3, one of these reciprocal-equational crossovers is the result of a second and third crossover since the forked locus is homozygous, but the other three double crossovers apparently involve a first and second crossover

because forked is heterozygous in these cases. Under such conditions it would be necessary to assume that a chiasma between sister chromatids must be prematurely terminalized to produce "non-disjunction." Since these chiasmata would be to the left of forked and in two cases to the left of cut, it is not impossible that premature terminalization might occur. It is also possible that these three reciprocal-equational crossovers are produced by second and third crossovers, and that the first crossover was a reciprocal to the right of forked, or that these exceptional crossovers are produced by the non-disjunction at the second maturation division.

The writer's hypothesis offers a simpler and more plausible explanation of "non-disjunction" than Janssen's partial chiasmatypy hypothesis, regardless of which interpretation of "non-disjunction" is correct.

RANDOM CROSSING OVER BETWEEN THE FOUR CHROMATIDS.

Crossing over is not limited to two of the four chromatids, because more than 50 per cent of the X and third chromosomes of *Drosophila* which emerge from the reduction division, have one or more crossovers. In 62 units of the X chromosome 54 per cent of the emerging chromosomes show at least one crossover (Anderson and Rhoades, 1931), and in the third chromosome 72.9 per cent of the chromosomes are crossovers (Redfield, 1930). If crossing over occurs only between the new chromatids as Belling (1931 a) has suggested, then not more than 50 per cent of the emerging chromosomes should be cross overs, regardless of the map length of the chromosome.

More recently Belling (1931 b) has assumed that "the old connecting fiber is indifferent as to which chromiole it will remain with." On this assumption crossing over would be at random between the four chromatids.

Belling's hypothesis can be modified to comply with certain cytological and genetic data. If the old connecting fibers usually remain with the old genes at the time the new chromatids are formed, then crossing over will usually occur between the two new chromatids as Belling (1931 a) has assumed. In some cases the old connecting fiber will unite a new and an old gene so that crossovers will occur between sister chromatids. Such crossovers, if sufficiently numerous, would result in random crossing over even if all crossovers at chiasmata were between the two new chromatids. Crossing over between sister chromatids would not be dependent on chromosome pairing and would be expected to occur with equal frequency in all regions of the chromosome.

On the writer's hypothesis random crossing over among the four chromatids can occur only if half-twists are sufficiently numerous in the paired sister chromatids. If the chromosomes are already split into sister chromatids at the time of meiotic pairing it would seem improbable that the same two non-sister chromatids would be paired throughout their length. If the secondary split occurs after pairing it would also be improbable that the sister chromatids would lie parallel throughout their length. One would expect some twists in the paired sister chromatids in either case. Such twists are found in both somatic and meiotic chromosomes.

In normal stocks of *Drosophila* and in cases of "non-disjunction," the genetic assortment of chromatids will be at random for the first crossover, because of their free assortment at the second maturation division. In attached-X stock, however, the random distribution at both first and second crossovers can be tested.

Random crossing over can occur in attached XXs, on the writer's theory, only if twists in paired sister chromatids are sufficiently numerous. Such half-twists could occur between the point of spindle fiber attachment and the first chiasma, or between the second and third chiasmata. (Diagram 10.) They could not occur between the first and second chiasmata without the formation of an additional chiasma between sister chromatids, but such chiasmata would be expected only in rare cases.

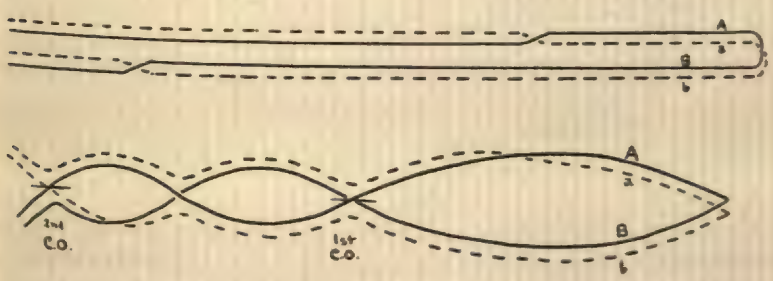


DIAGRAM 10

Only two types of first crossovers need be considered; (0) no twists in either pair of sister chromatids between the attachment point and the first crossover chiasma, and (1 a) one half twist in only one pair of sister chromatids, Aa. The other two types, (1 b) a half twist in chromatids Bb, or (1a–1b) in both pairs of sister chromatids, need not be considered since they are reciprocal to the first two types.

Between the first and second crossovers four types of chromatid association must be considered if crossing over is at random. There may be (0) no twists in either pair of sister chromatids, (1 a) one half-twist in chromatids Aa, (1 b) one half twist in chromatids Bb,

and (1a–1b) a half twist in each of the paired sister chromatids. If such half-twists are frequent there might be several of them between the point of attachment and the first crossover, or between crossovers, but if these twists occur at random they will produce the same types and proportions of crossovers as expected on the assumption that the above four types occur in equal proportions.

If no half twists occur as we would expect types (O) and (1a–1b) to be formed in equal proportions, but no types 1a or 1b would be expected. At a given chiasma crossing over could occur between A and b chromatids, or between B and a. If the first crossover is between A and b the second crossover may occur between A and b or between a and B. With no half twists in pairs of sister chromatids only equational crossovers could occur in attached XXs.

If chiasmata are produced by previous crossovers, the modification of Belling's hypothesis would seem to be the most plausible explanation of the mechanism involved. If sufficient crossovers occur between sister chromatids, the detectable crossovers will be at random between the four chromatids. The association of chromatids shown in diagram 11 will give the same random crossing over as direct crossing over between A and B or b, and B with either A or a.

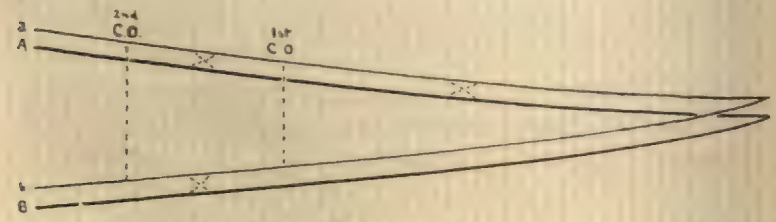


DIAGRAM 11

The detectable crossovers are shown by the lines connecting the two daughter chromatids. Only two types of chromatid association need be considered between the point of attachment of the X chromosomes and the first crossover;—(O) no crossovers occur in either pair of sister chromatids, and (1a) a sister crossover occurs in the Aa pair of chromatids. Between the first and second chiasmata there may be, (O) no sister crossovers, (1a) an excess of 1 sister crossover in chromatid Aa, (1b) an excess of 1 sister crossover in chromatid Bb, or (1a–1b) an equal number of sister crossovers in each of the pairs of sister chromatids.

On either theory we have 8 types of chromatid association in the attached X bivalents, which produce 16 classes of crossovers. The results of random crossing over at two points in the bivalent attached X chromosomes are shown in table 2.

TABLE 2

Types of chromatid association resulting from random crossing over at two points in attached X chromosomes.

C.O. Class	1st C.O. Sax	1st C.O. Bell.	2nd C.O. S. or B.	Crossover types	1st crossovers eq.	1st crossovers rec.	2nd C.O. types 1	2nd C.O. types 2	2nd C.O. types 3	homozygosis 1st Xta	homozygosis 2nd Xta
1	0	1a	0	aaa/bab aba/bbb	2			2		2	
2	0	1a	1a	baa/aab aba/bbb	2			2		2	
3	0	1a	1b	aaa/bab bba/abb	2			2		2	
4	0	1a	1a, 1b	baa/aab bba/abb	2			2		2	
5	1a	0	0	aba/bab aaa/bbb		1			1		
6	1a	0	1a	aba/aab baa/bbb	1	1	1				2
7	1a	0	1b	bba/bab aaa/abb	1	1	1				2
8	1a	0	1a, 1b	bba/aab baa/abb		2					
					10	— 5	2	— 8	— 1	8/16	4/16

In the second column are listed the types of first crossovers which have been considered on the writer's hypothesis and on the modified hypothesis of Belling. The genetic constitution of the attached XXs which pass to the egg cell are indicated under crossover types. Difference between chromatids A and a, or B and b, are not indicated since they cannot be detected by genetic tests. The first detectable crossovers from the attachment point are shown to occur in the ratio of 2 : 1 if crossing over is at random. Three types of second crossovers occur:—(1) equationals homozygous to the left $\left(\frac{ab}{aa} \text{ or } \frac{bb}{ba}\right)$, (2) equational crossovers homozygous to the right $\left(\frac{ab}{bb} \text{ or } \frac{aa}{ba}\right)$, or (3) reciprocal crossovers $\left(\frac{ab}{ba} \text{ or } \frac{ab}{ba}\right)$. With random crossing over these types should appear in the ratio of 2 : 8 : 1. At the left of the first crossover chiasma one-half of the attached X chromosomes should be homozygous, and one-fourth should be homozygous recessives. At the left of the second crossover chiasma one-fourth of the attached XXs should be homozygous and one-eighth recessives.

If crossing over is at random the first crossovers from the spindle fiber end in attached XX should be equationals and reciprocals in the proportion of 2 : 1 (Table 2). Anderson (1925) found equational and reciprocals in his attached X data, in the proportion of 29.7 to 15.6. Although there is a slight excess of equationals the ration is very near random expectation. If equational and reciprocal first crossovers occur in the ratio of 2.1 then the percentage of homozygous recessives should be half of the crossover distance between the spindle fiber and the first crossover. For forked, which is about 10 units from the spindle fiber, the percentage of recessives in attached XXs was found to be 5.2 by Anderson, 4.9 by Rhoades, and 5.1 by Sturtevant. The genetic evidence indicates that the chromatids are assorted at random at the first crossover.

Random assortment of chromatids would be expected if there is an average of 0.5 or more half-twists or sister crossovers between the attachment point and the first crossover. Even with relatively few half-twists or sister chromatid crossovers in the X chromosome, random crossing over might be expected at the first crossover chiasma because the region between the spindle fiber and the first crossover would usually include more than half of the length of the chromosome (Stern 1931).

The randomness of chromatid association at the second crossover can be determined from the proportions of types of second crossovers in attached X and XXs from "non-disjunction." The non-

disjunction types of crossovers can be derived from table 2 by combining each two crossover combinations into the four possible combinations expected if non-disjunction is due to non-conjugation at metaphase. The classes of crossover combinations will be doubled but the proportion of types of second crossovers will remain the same as shown in table 2.

The available data on types of second crossovers are presented in table 3.

TABLE 3.

Types of 2nd crossovers. (Cf. Table 2)

	(1)	(2)	(3)
Anderson 1925 Table 6.....	1 (.6)	7 (3.0)	1 (.6)
Anderson 1929 Table 24–25.....	1 (.05)	6 (.25)	1 (.09)
Anderson 1931 Table 3.....	3	3	1

The attached X and high non-disjunction data show a lower proportion of type 1 second crossovers than would be expected if crossing over is at random, but the numbers are too small to be of much value. In the X-ray non-disjunction data there is an excess of type 1 second crossovers caused by non-disjunction at the second division.

The third test of randomness of crossing over can be made by comparing the amount of homozygosis in attached X chromosomes with the amount expected on random assortment of chromatids. The amount of homozygosis at the left end of attached X, or XXs from non-disjunction, is dependent on the number and types of crossovers. The amount of homozygosis at the left of first and second crossover chiasmata is shown in table 2. Fifty per cent of the two emerging X chromosomes should be homozygous to the left of the first crossover and twenty-five per cent at the left of the second.

It is first necessary to calculate the number of chiasmata which produce crossovers. As Belling (1931 b) has pointed out, the relations between crossover chiasmata and crossing over is as follows if crossing over is at random.

TABLE 4

	Crossovers in emerging single chromatids				
	0	1	2	3	4
Number of crossover chiasmata	0 = 16				
	1 = 8	8			
	2 = 4	8	4		
	3 = 2	6	6	2	
	4 = 1	4	6	4	1

The data from Anderson and Rhoades (1931) table 1 have been used for the calculation of the frequency of chiasmata which produce

crossovers in the bivalent X chromosomes. Crossover recombinations are shown for 26,908 X-chromosomes of which 46 per cent showed no crossing over in the 62 units between forked and scute, 46 per cent were single crossovers, 7.6 per cent were double crossovers, 0.2 per cent were triple crossovers and .01 per cent were quadruple crossovers.

If crossing over is at random chiasma frequency can be obtained from crossover frequency as shown in table 5.

TABLE 5

Calculation of chiasma frequency based on crossover frequency in the X chromosome of *Drosophila*

	Number of crossovers per chromosome				
	0 46%	1 46%	2 7.6%	3 0.2%	4 .01%
−4th Xta.....	.01	.04	.06	.04	x16 = .16
	45.00	45.96	7.54	.16	
−3rd Xta.....	.16	.48	.48	x8 = 1.3	
	45.83	45.48	7.06		
−2d Xta.....	7.06	14.12	x4 = 28.2		
	38.77 31.36	31.36			
−1st Xta.....	8.41	x2 = 62.7			

Total chiasmata in bivalents.

None	Single	Double	Triple	Quadruple
8.4%	62.7%	28.2%	1.3%	.2%

Since quadruple chiasmata, if crossing over is at random, should produce crossover chromatids in the proportion of 1 non-crossover, 4 singles, 6 doubles, 4 triples, and 1 quadruple, it is necessary to subtract proportional percentages from each class of crossovers, and repeat for triples, doubles, and singles in proper proportions. Only one chromatid in 16 produced by quadruple chiasmata (which produce crossovers) will be a quadruple crossover, so the percentage of quadruple crossovers must be multiplied by 16 to obtain the number of quadruple chiasmata. Similar calculations are used to obtain chiasmata frequency from single, double, and triple crossovers.

With the above frequency of single, double, and triple chiasmata it is possible to determine the percentage of homozygosis expected 62 units from the spindle fiber end of the two X chromosomes from attached X and non-disjunction stock. The percentage of homozy-

gosis at the left of the first crossover chiasma is 50, the second 25, (Table 2) and the third 37.5, if crossing over is at random. For homozygous recessives these percentages are 25, 12.5, and 18.75 respectively. The following table shows the percentage of homozygous recessives expected 62 units from the spindle fiber attachment in XX chromosomes.

Chiasmata =	Single	Double	Triple
	62.7%	28.2%	1.3%
% homo. recessives =	15.67%	3.52%	.24% = 19.4%

We would expect then, if crossing over is at random, to find 19.4 per cent of homozygous recessives in attached XXs at a point 62 units from the right end of the chromosome. The percentage of homozygosis found is significantly lower than expected. Sturtevant (1931) found 17.1 per cent homozygosis for scute, which is about 72 units from the right end of the X chromosome. This analysis was based on approximately 25,000 flies. Rhoades (1931) found about 18.6 per cent homozygosis for scute, but for ruby, which is about 64 units from the spindle fiber attachment, the percentage of homozygosis was found to be 17.7. Counts were made on about 42,000 flies. At a point 62 units from the spindle fiber the percentage of homozygosis recessives would be about 17.4 where 19.4 per cent would be expected on the basis of random crossing over.

Anderson's attached X data shows a similar discrepancy between the percentage of homozygosis found and the percentage expected on random crossing over. Chromosomes homozygous for the forked locus are assumed to have crossed over to the right of forked, and such chromatids are classed as crossovers in this region. Only one of the chromatids, equational at forked, is a crossover to the right of forked, but both are included to make up for the reciprocal crossovers to the right of forked which cannot be detected from the data. Considering these crossovers to the right of forked, there are 59.5 per cent of the chromatids with no crossovers, 37.2 per cent with one, and 3.3 per cent with two. In terms of crossover chiasmata, 25.6 per cent of the bivalent chromosomes have no chiasmata between the spindle fiber and end, 61.2 per cent have one chiasma, and 13.2 per cent have double chiasmata which break. If crossing over is at random the percentage of homozygosis for cut should be 16.5 per cent in the XX chromosomes listed in Anderson's table 6. The percentage of homozygosis actually found was 15.5, although for tan, still further to the right, the value was 16.1.

The percentage of homozygous recessives at the left end of attached X chromosomes is lower than expected if crossing over is at random. But, as Anderson and others have suggested, the

lower viability of the homozygous recessive segregates would reduce the percentage of these classes so that the true value might well approach the percentage expected on random assortment.

If there is any significant deficiency of homozygosis in attached X chromosomes, it would indicate that second cross-overs are not entirely at random. On the writer's hypothesis such a deficiency could be attributed to few half twists between the first and second cross over. For instance, if the average frequency of half twists were 0.25, the percentage of homozygous recessives 62 units from the fiber would be only 17.6 instead of 19.4 expected on random assortment. Belling's recent theory should always give random assortment for all cross overs. The modification of Belling's theory suggested by the writer would also fail to account for any deficiency of homozygous recessives. If crossing over is invariably at random between the four chromatids, Belling's theory would seem to be the most valid interpretation of the mechanism of crossing over. If, however, crossing over is not entirely at random, the writer's hypothesis seems to offer the only solution. Although there is a deficiency of homozygous segregates from attached X chromosomes, the nature of the genetic evidence does not justify any final conclusion concerning random assortment of the chromatids at the second cross over.

CHROMOSOME PAIRING AND CROSSING OVER.

When crossing over is eliminated in the *Drosophila* female there is also a loose association of homologous chromosomes. (Gowen 1922, 1928.) This behavior is undoubtedly analagous to the case of asynapsis in *Zea* (Beadle 1930). A decrease in crossing over may also be caused by inversions and translocations. Dr. Anderson informs me that his high non-disjunction line was caused by an inversion. In this case the decrease in crossing over was also associated with an increase in "non-disjunction" or failure of chromosome pairing. Dobzhansky (1931, 1932) has found that crossing over is decreased and non-disjunction increased in flies heterozygous for translocations. This behavior is attributed to conflicting attractions between homologous chromosome segments.

On either theory of crossing over the reduction or elimination of crossing over could be attributed to a differential rate of chromosome pairing compared with chromatid organization. At pachytene all four chromatids are associated, at diplotene only two chromatids can be associated and at telophase the two chromatids are united only at the spindle fiber constriction. If chromosome pairing is delayed then the sister chromatids might be at a stage commonly

found at diplotene, before the homologous chromosomes are paired, so that no chiasmata could be formed. In the cases of inversion no pairing of homologous genes would occur between inverted and normal chromosome segments and no crossovers could be produced in such regions. In heterozygous translocations chromosome pairing is delayed so that few chiasmata can be formed.

The genetic and cytological evidence shows that crossing over is most frequent at the distal end of the X chromosome (Painter, 1931) and at the distal ends of the third chromosome (Dobzhansky, 1930). This localization of crossing over would seem to indicate that chromosome pairing in *Drosophila* begins at the distal ends of the chromosomes and proceeds towards the spindle fiber. Crossing over would occur at the ends of the chromosomes because the chromatids are not sufficiently differentiated to prevent chiasma formation, but towards the spindle fiber the paired sister chromatids become so united that chiasma formation is no longer possible. Since chiasma formation is associated with crossing over, on either theory, there would be few crossovers in the spindle fiber region and frequent crossovers at the distal ends of the chromosomes.

Crossing over is increased in the X chromosome and in the autosomes of *Drosophila* by changes in temperature and by X-rays. (Plough 1917; Stern 1926; Muller 1925, 1926.) The increase in crossing over occurs primarily in the region of the spindle fiber attachment, but not in regions where crossing over is frequent in untreated flies. This behavior could be attributed to an acceleration of chromosome pairing so that in the region of the fiber attachment the chromosomes would be paired before the sister chromatids had sufficiently developed to prevent chiasma formation. Thus crossing over would be increased in the spindle fiber region of the chromosome.

Differences in types of chromosome association at meiosis might also be attributed to differences in the region where pairing begins. If pairing begins at the spindle fiber and proceeds slowly toward the ends, the chiasmata would be localized in the region of the fiber, as is the case in *Fritillaria* (Newton and Darlington, 1930). If pairing is completed before sister chromatids are sufficiently developed, then chiasmata will not be localized, but will be more or less uniformly distributed along the bivalent chromosome as is the case in *Lathyrus*, *Lilium* and *Vicia*. If pairing begins at the ends and proceeds slowly toward the middle, or if the sister chromatids develop rapidly, then the chiasmata will be terminal, as found in the Solanaceae.

Graubard (1932) has recently presented evidence, based on cross-

ing over in homologous chromosomes heterozygous for an inversion, which seems to indicate that pairing begins at the spindle fiber in the second chromosome of *Drosophila*.

SUMMARY.

A study of chromosome behavior at different stages of meiosis in a number of species of plants, together with an analysis of the genetic evidence in *Drosophila*, has provided some critical evidence in regard to the cytological mechanism of crossing over.

Janssen's partial chiasmatypy hypothesis has been supported by Darlington, Belling and Maeda, but it is shown that there is no critical evidence in favor of this theory. Belling has offered the only explanation of the mechanism of crossing over in connection with Janssen's hypothesis, but this explanation is not in accord with certain cytological and genetic evidence. Neither Belling's theory of crossing over nor Darlington's theory of meiosis can be reconciled with the cytological work of Robertson, Kaufmann and Sharp.

According to the writer's hypothesis crossing over is caused by breaks in two of the chromatids at a chiasma so that crossing over should be correlated with a reduction in the number of chiasmata between the diplotene and diakinesis stages of meiosis. In *Callisia repens* there is a considerable reduction in number of chiasmata per bivalent between the diplotene and metaphase stages. The work of other cytologists shows that the numbers of nodes or chiasmata are reduced during the prophases of meiosis in *Tulipa*, *Lilium*, *Primula*, *Rosa* and *Matthiola*.

The association of non-disjunction with a reduction in crossing over is apparently due to a weak association of homologous chromosomes in high non-disjunction lines of *Drosophila*. Where crossovers occur in the X chromosomes which pass to the same egg cell the partial chiasmatypy hypothesis would necessitate premature terminalization of chiasmata, in some cases for practically the entire crossover length of the X chromosome. On the writer's hypothesis non-disjunction with crossing over is attributed to the formation of few chiasmata all of which are broken before diakinesis, resulting in a weak association of homologous chromosomes.

The ratio of different types of second crossovers and the percentage of homozygosis in attached X chromosomes in *Drosophila* suggests that the second crossover may not be at random between any two of the four chromatids. If crossing over is not random at the second crossover the writer's hypothesis will account for the deficiency of homozygosis. It is impossible to account for these

genetic results on Belling's hypothesis or on any logical modification of his hypothesis.

Localization of chiasmata and crossovers is attributed to the type of chromosome pairing and to the relation between chromosome pairing and chromatid development.

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DESCRIPTION OF PLATE 44.

Meiosis in the pollen mother cells of Callisia repens. Magnification × 3000

Figure 1. Pachytene stage. No continuous spireme observed at any stage in meiosis.

Figure 2. Late pachytene. The six chromosomes can be observed more clearly at this stage. The nucleolus is always attached to one of the short bivalents.

Figure 3. Early diplotene showing the chromosomes forming the nodes and internodes.

Figure 4. Diplotene stage showing the number of nodes, most of which are probably chiasmata.

Figure 5. Early diakinesis showing the reduction in number of nodes or chiasmata compared with the diplotene stage.

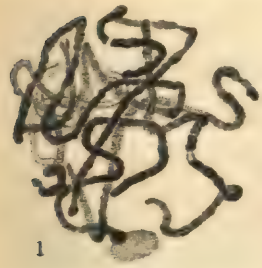
Figures 6 and 7. Diakinesis. The nucleolus disappears between diakinesis and first metaphase.

Figure 8. Metaphase of the first meiotic division. The chromosomes show the coiled chromonemata.

Figure 9. Late anaphase showing spindle fiber attachment points. Two of the six chromosomes have a median attachment while four have terminal fiber attachments. Compare with text-figure 1.

Figure 10. The nucleolus seems to be attached to the the same chromosome in all cases. This chromosome at late diplotene is shown at the left. Typical diplotene stages are shown in the other five chromosomes.

Figure 11. The chromosome at the left is from a p. m. c. at early diakinesis. The other chromosomes show the number of chiasmata at diakinesis. Note the reduction in length of the bivalent from pachytene to diakinesis and the reduction in the number of nodes or chiasmata between diplotene and diakinesis.



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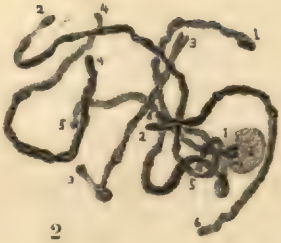

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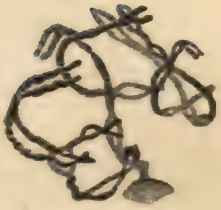

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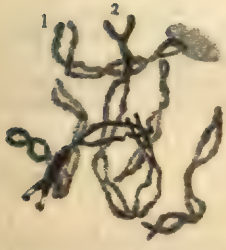

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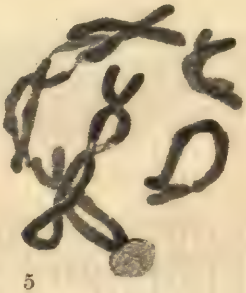

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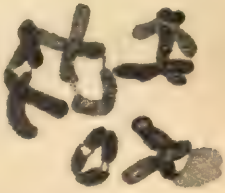

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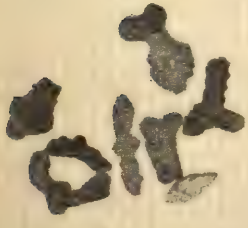

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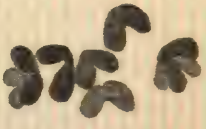

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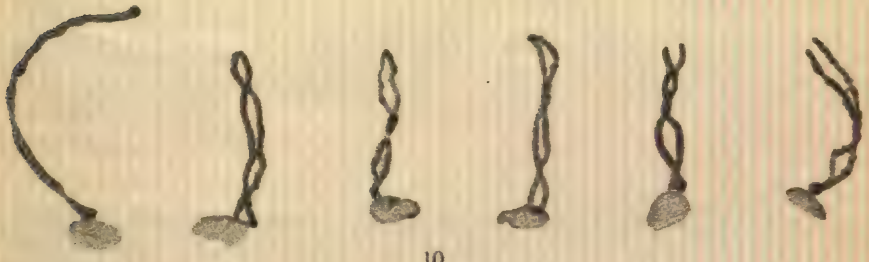

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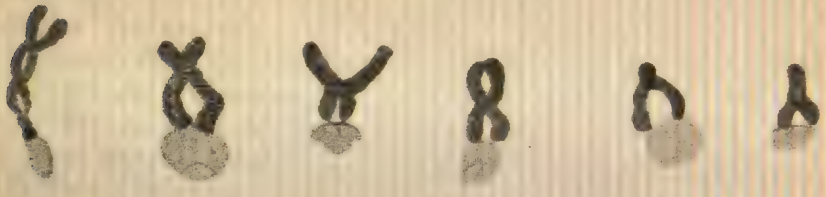

11

Mechanism of Crossing Over

CONTRIBUTIONS TO THE TRADESCANTIA PROBLEM

EDGAR ANDERSON AND D. G. DIEHL

With plate 45 and three text figures

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Tradescantias of the St. Louis Region
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INTRODUCTION

THE GENUS *Tradescantia* is as taxonomically difficult as it is cytologically superb. On the one hand its fugitive flower parts render herbarium specimens a poor record of the living plant; on the other those very phenomena (fragmentation, polyploidy, ring-formation) which attract the cytologist, produce intricate and puzzling relationships between species. It would remain a difficult genus to monograph if its floral characteristics were as well preserved in herbarium specimens as are those of the genus *Aster* for instance. Monographing *Tradescantia* from herbarium specimens alone would indeed be almost like working with a collection of Compositae from which the flowerheads had been removed.

Yet though the genus is an extraordinarily difficult one from the orthodox taxonomic viewpoint, it has much to recommend it for cyto-genetic studies. It grows easily from seeds or transplants and can withstand all sorts of mistreatment. It has a long-blooming period and artificial pollinations are not difficult to make. The chromosomes are enormous (they can sometimes be counted under low power) and are readily studied in smear preparations. Both tetraploid and diploid species and varieties occur in nature, and white, blue, and pink forms are already available for genetical analysis. It is by all odds one of the most promising native American genera for cyto-genetic investigations. Yet fundamental conclusions as to the evolutionary importance of cytogenetic phenomena will not be possible until they can be viewed against a background of sound morphological and taxonomical research.

If those geneticists and cytologists who are studying *Tradescantia*

would record, in addition to cytological details, the exact source of their material, and the nature of the pubescence on the leaves, on the sepals, and on the ovary, it would be possible to apply their findings to other problems besides those of chromosome structure.

TRADESCANTIA IN THE ST. LOUIS REGION

The following paper reports a preliminary cytological and genetical analysis of the Tradescantias of the Saint Louis region. It is a "report of progress" in an attempt *to describe these species as they occur in that region, to evaluate the forces which have produced them, and to measure the evolutionary processes which are taking place within them at the present time.*

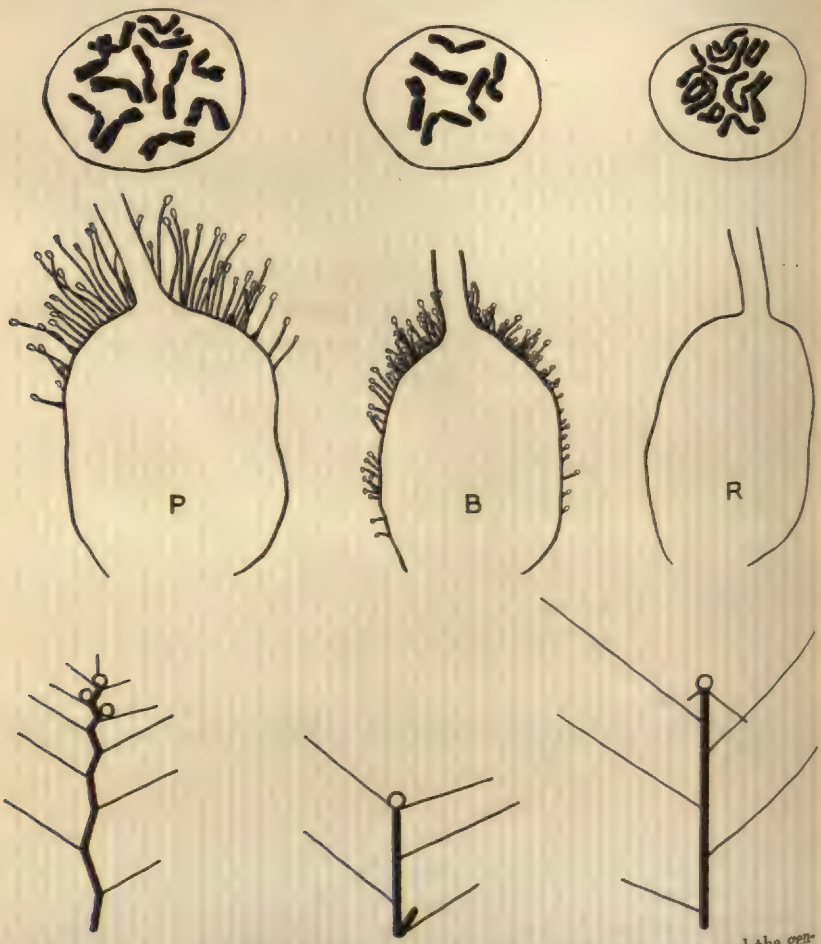

Figure 1. A comparison of the chromosome complement, the ovary, and the general habit of *T. pilosa* (left), *T. bracteata* (middle), and *T. reflexa* (right). Complete explanation in the text.

There are at least three species of *Tradescantia* in eastern Missouri. There may be more; there cannot possibly be fewer. If there eventually prove to be ten or twenty species they will even then fall into three groups. These three groups are separated from each other morphologically, ecologically, and cytologically, We are identifying them provisionally as *Tradescantia pilosa* Lehm., *T. reflexa* Raf., and *T. bracteata* Small. There are other Tradescantias in the state but we did not find them in the area covered by this study.

The outstanding differences between the three species are shown, somewhat diagrammatically, in figure 1. The middle row shows camera lucida drawings of the ovary and its pubescence. The lower row, reduced to scale from actual specimens, shows leaf size and number, length of node and number of nodes, etc. The upper row shows the gametic chromosome complement from camera lucida drawings of smears of pollen grain mitoses.

Tradescantia reflexa

Tradescantia reflexa is by far the commonest of the three species. It is tall and slender, glaucous throughout, with narrow, reflexed bracts. The ovary is completely glabrous or at most bears two or three tiny hairs at the base of the style. At Eureka, Missouri it was found on the limestone "glades" of the region. These are dry, stony hillsides with a semi-arid flora. They were apparently in this area the original home of the species, from which it has spread to railroad rights of way, dump-heaps, and the like. There was no apparent morphological or cytological difference between these "glade" populations and those along the railroad tracks.

Several of the colonies included variants, which had they not been connected with the normal type by a complete series of intermediates, might have been considered as taxonomically distinct. At Algonquin Station, Webster Groves, there were several very dwarf plants less than a foot high, but there were also a number of intermediates between these dwarfs and the rest of the colony. At Hamburg, Missouri, the opposite extreme was found, for several of the plants in this colony measured well over six feet in height. The most outstanding variation was seen at Hillsboro, Missouri, along a sandstone outcrop. The plants of this colony were all characterized by scattered hairs on the calyx in addition to the normal tuft usually found in *T. reflexa*. They were also differentiated by being early-flowering and it is possible that they are varietally distinct from the other plants of *T. reflexa* studied. For the present we have included them under *T. reflexa*. It is quite possible that they may be the result of hybridization with *T. bracteata*, In all of the above cases,

these peculiar forms were examined cytologically (both P M C and pollen divisions) and showed no divergences in chromosome numbers. Nineteen plants were recorded, as shown in Table 1. All were tetraploids (2n = 24). Many other plants were examined, and their chromosome numbers determined, but no definite record was made. Unfortunately the only plant showing a fragment chromosome was among these unrecorded individuals and it is not possible to say from which locality it came.

In spite of its variability, *T. reflexa* remains an easily recognizable unit over a very wide area. Colonies in south-western Michigan (Schoolcraft) and in southern Illinois (Ullin) seemed essentially the same as those examined in Missouri. The following collections available in herbaria represent plants morphologically similar to those we studied cytologically: *Lansing*, no. 3121, Mansfield, Mo.; *Lansing*, no. 3037, Cedar Gap, Mo.; *Ridgway*, no. 2116, Olney, Ill.

Examination of reduction divisions showed that *T. reflexa* was not only a tetraploid but was practically an auto-tetraploid. There was a very strong tendency for the chromosomes to conjugate in sets of four, the number of quadrivalents per PMC varying from 0 to 6. A count of ten PMC from a single smear of *T. reflexa* gave the following frequencies:

No. of times observed	No. of II's	No. of IV's
1	0	6
2	2	5
2	4	4
1	6	3
3	8	2
1	10	1

In the material examined the separation of quadrivalents was not at random. There was a very strong tendency (about 10 to 1) for adjacent chromosomes to pass to opposite poles. The data are consistent with the hypothesis that *T. reflexa* is an auto-tetraploid in which there is a slight differentiation between the two diploid sets of which it is made up. Its chromosome complement might be diagrammed as follows:

AA′ BB′ CC′ DD′ EE′ FF′
AA′ BB′ CC′ DD′ EE′ FF′

Tradescantia bracteata

As it occurs in Missouri this is a dwarf species seldom over a foot (3 dm.) in height. The ovary is covered with short glandular hairs (fig. 1). The flowering period is comparatively short and as the seed ripens the leaves die down and the plants pass through the summer in a semi-dormant condition. The flowers are more bril-

liant in color than those of *T. pilosa* or *T. reflexa*. Pink-flowered plants and blue-flowered plants are usually found growing together and albinos are not uncommon. The following collections represent material essentially similar to that which we studied cytologically: *Bush*, no. 684, Watson, Mo.; *Bush*, no. 336, Grandin, Mo.; *Davis*, no. 4403, Whiteside, Mo.

Tradescantia bracteata grows in abundance on rich black soil along roadsides and in wet meadows in the bottomland of the Mississippi River at Portage des Sioux, Missouri. The chromosome numbers of six plants from this locality were determined as is indicated in Table 1. All were diploids (2n = 12). One had a small fragment chromosome.

Tradescantia pilosa

This is by far the most distinct of the Missouri Tradescantias. In the St. Louis area it occurs only in shady situations, usually in rich sandy soil at the base of sandstone cliffs or in pockets on the face of the cliff. Since sandstone areas in eastern Missouri are mainly confined to a long narrow outcrop of St. Peter sandstone, *T. pilosa* is an uncommon species there. It was found in abundance

TABLE 1

Chromosome Numbers of wild-growing Tradescantias from eastern Missouri. (Including a few plants of *T. reflexa* from outside that region.)

Source	P M C	Pollen grain mitosis
T. reflexa		
Hillsboro, Mo.	n = 12	—
Hillsboro, Mo.	—	n = 12
South Webster, Mo.	*—	n = 12
Eureka, Mo.	n = 12	n = 12
Hamburg, Mo.	—	n = 12
Hamburg, Mo.	—	n = 12
? , Mo.	—	n = 12 + f
Antonio, Mo.	—	n = 12
Ullin, Ill.	—	n = 12
Ullin, Ill.	—	n = 12
Ullin, Ill.	—	n = 12
Ullin, Ill.	—	n = 12
La Crosse, Wis.	—	n = 12
Schoolcraft, Mich.	n = 12	n = 12
Schoolcraft, Mich.	—	n = 12
Schoolcraft, Mich.	—	n = 12
Schoolcraft, Mich.	—	n = 12
T. pilosa		
Hermann, Mo.	n = 12	—
Hermann, Mo.	—	n = 12 + f
Marthasville, Mo.	n = 12	—
Marthasville, Mo.	—	n = 12
T. bracteata		
Portage des Sioux, Mo.	n = 6	n = 6
Portage des Sioux, Mo.	—	n = 6 + f
Portage des Sioux, Mo.	—	n = 6
Portage des Sioux, Mo.	—	n = 6
Portage des Sioux, Mo.	—	n = 6
Portage des Sioux, Mo.	—	n = 6

at Marthasville, Hermann, Ashland, and Winfield, Mo. The following collections, available in many of the larger herbaria, represent material essentially similar to that which we studied cytologically: *Eggert*, St. Louis, Mo.; *Davis*, no. 3604, Hannibal, Missouri; *Eggert*, Hematite, Mo.; *Palmer*, no. 34,802, Pontiac, Missouri.

In general aspect *T. pilosa* is entirely different from any other Missouri Tradescantia. The stem is tall and zig-zag, the entire plant is sparingly pilose. The flowering season is late (July to August). The ovary bears long scattered hairs with relatively small glands at their tips. (Fig. 1). The chromosome numbers of 4 plants were determined; as reported in Table 1. All were tetraploids (2n = 24).

A COMPARISON OF VARIATION IN DIPLOID AND TETRAPLOID SPECIES

As has been reported above, *T. reflexa* (in Missouri, Illinois, Wisconsin, and western Michigan) was found to be a tetraploid species. *T. bracteata*, on the other hand, was a diploid. That is, *T. bracteata* like most normal animals and plants had its chromosomes in sets of twos. Those of *T. reflexa* on the other hand, were in sets of fours. This tetraploid condition should have a very marked effect upon the nature of individual differences in the two species. It should increase not only the proportion of intermediates but the number of intermediate types. An example may make this more clear.

Let us consider the simplest possible case, a single factor difference, albinism, for example, as it might be expected to operate in the diploid *T. bracteata*, on the one hand, and in the tetraploid, *T. reflexa* on the other. The inheritance of albinism in Tradescantia, so far as we know, has not actually been studied but the circumstantial evidence from forms existing in nature is all in accord with the hypothesis that as in practically all other flowering plants it is due to a single recessive gene. If we represent the gene for albinism by a, and its normal allelomorph by A, an albino plant of *T. bracteata* will be of the genetical composition (aa) and a pure-breeding full-colored plant will be (AA). Crossing the two will give us a heterozygous F_1 (Aa) which, selfed or crossed *inter se*, will produce the familiar ¼(AA) ½(Aa) ¼(aa) in the second generation. That is, in the diploid species, as regards the gene for albinism, there can be only three possible genetic types, the pure albino (aa) the pure-breeding normal (AA) and the heterozygote (Aa).

In the tetraploid *T. reflexa*, on the other hand, a pure albino must have a gene for albinism in each of the four sets of chromosomes and will be of the genetic constitution (aaaa). A cross with a homozygous (true-breeding) full-colored individual (AAAA) will in the

second generation produce full-colored (AAAA), albinos (aaaa), and three genetically different types of intermediates (AAAa), (AAaa), and (Aaaa). Whereas, in the diploid there were only three possible genetic types, there will be five in the tetraploid.

TABLE 2

A comparison of a cross between albinism and color in a diploid and an autotetraploid.

	Diploid	Tetraploid
Color parent	AA	AAAA
Albino parent	aa	aaaa
First generation	Aa	AAaa
Second generation	AA....25%	AAAA.... 2.8%
		AAAa....22.2%
	Aa....50%	AAaa.....50.0%
		Aaaa.....22.8%
	aa.....25%	aaaa..... 2.8%

The differences between the two examples are set out diagrammatically in Table 2. It will be seen that in the tetraploid second generation as compared with the diploid, there are (1) three kinds of intermediates instead of one, (2) a much higher proportion of intermediates (94% instead of 50%). This will result in the tetraploid being tremendously more variable (using the word in its biological sense). In our hypothetical case of albinism in a population breeding at random and with, as is usually the case, the full-colored forms somewhat more variable than the albinos, we may expect in the diploid a large number of dark blues (AA), a large number of intermediates (Aa) and a few whites (aa). With exactly the same premises we will find in the tetraploids, very few dark blues and a large proportion of intermediates of various shades of blue and a very few pure albinos or none at all.

The same situation which has been outlined for albinism will apply to all the other genes; all will be present in sets of four instead of in sets of two. The change from pink flower to blue flower is apparently mainly due to a single factor. In a population of *T. bracteata* segregating for albinism and for pink we would expect to find only light and dark pink, light and dark blue, and white. In a similar population of *T. reflexa* we might expect to find blues, various intermediate magentas, and perhaps a few pinks, all in many degrees of color intensity.

These hypothetical deductions (which had been worked out from greenhouse material before we examined wild populations) are interesting because they agree exactly with what we actually *did* find. Large populations of *T. reflexa* were studied at five localities and *T. bracteata* was studied at two widely separated ones. The

data are summarized in Table 3. Those on flower color are difficult to present because of the variability of the tetraploids. In the diploid *T. bracteata* it was a simple matter to score the flowers as either pink or blue. Among the plants of *T. reflexa* any attempt at classification (aside from the extremely rare pure pinks) was extremely difficult and frankly artificial. In Table 3 an attempt is made to record the prevailing color types in each colony and the actual number of pure pinks or pure albinos. In another section of this paper one colony is taken up in as great detail as possible. The variation there reported is typical.

The number of genes segregating in a wild population is probably to be numbered by the thousands. For each of these the same situation will prevail which has been outlined in detail for those for pink and for albinism. The net result will be a tremendous increase in the total possible number of geneotypes in each population, and in the number and proportion of intermediates. Nearly every taxonomist who has worked with *T. reflexa* has commented on its peculiar variability. While the fact that it is a tetraploid (and practically an auto-tetraploid) does not explain all the peculiarities met with in this species, it is responsible for many of them.

Students of the group have commented on the fact that some species of *Tradescantia* customarily produce both pink-flowered and blue-flowered plants, while other species do not. Rose (1899) for instance, has included this characteristic in forming his specific descriptions. The cytological and genetical data reported above provide a logical explanation for this interesting difference.

TABLE 3

Variation in flower color in populations of *T. reflexa* and *T. bracteata*.

SPECIES	LOCALITY	PREVAILING FLOWER COLORS	NO. OF PURE PINKS	NO. OF PURE WHITES
T. reflexa	Algonquin, Webster Groves, Missouri	Blue, blue-magenta, magenta, magenta-pink	1	0
T. reflexa	S. Webster, Missouri	Blue, magenta-blue, magenta-pink	0	0
T. reflexa	Hamburg, Missouri	Dark-blue, blue, blue-magenta	0	0
T. reflexa	Hillsboro, Missouri	Dark-blue, blue	0	0
T. reflexa	Ullin, Illinois	Dark-blue, magenta, magenta-pink	0	0
T. reflexa	Schoolcraft, Mich.	Dark-blue, grey-blue, deep magenta, pale magenta	0	0
T. bracteata	Portage des Sioux, Mo.	Bright blue 39, blue-magenta 1	14	0
T. bracteata	Tama, Iowa	Blue 1100 ±	380 ±	6

VEGETATIVE REPRODUCTION IN TRADESCANTIA

Throughout his paper on the Tradescantiae, Darlington (1929) has assumed that *T. virginiana*[1] is propagated mainly, if not entirely, by vegetative means. He presents no experimental evidence for this conclusion other than to describe the cytological conditions which according to his theories make vegetative propagation obligatory. The following quotations are representative of his point of view: p. 254. "The fact that we have forms of *Tradescantia virginiana* with fragments that do not answer to the requirements of meiosis merely *emphasizes the unimportance of sexual reproduction in preserving this species*."

P. 254. "*T. virginiana* itself has drifted into an evolutionary back water in which *vegetative propagation has become excessively important.*

P. 278. "In *Tradescantia crassifolia* and *T. bracteata*, however, the various abnormalities must *reduce seed-production to negligible proportions if they reproduce themselves normally.*"

P. 279. "More recently Bush (1904) for example, has distinguished 18 different species from Texas alone; these would probably all resemble the types described cytologically [They do not. The seven that we have examined so far have been diploids.] and would be interfertile so far as they were fertile at all. It need hardly be said that none of them would be consistently true-breeding."

As will be demonstrated below this very logical theory is completely erroneous. We have not found the slightest scrap of evidence to support the thesis that tetraploid Tradescantias like *T. virginiana* and *T. reflexa* are dependent upon vegetative propagation. On the other hand we have found abundant evidence that it is even less highly developed among them than among the simple diploids from which they probably arose. Darlington's erroneous conclusions are probably due in part to his ignorance of the fact that these species are usually self-sterile.[2] Isolated specimens in gardens or greenhouses cannot be made to set seed. Moore (1917) had previously reported the fact, and we have been unable to obtain seed from self-pollination of any of the plants we have under cultivation, though they set seed readily in cross-pollinations.

There are two ways in which Darlington's hypothesis can be tested. We have evidence on both points.

[1] It should be remembered that Darlington includes not only the closely related species *T. reflexa*, but also the southwestern low-growing species *T. bracteata*, *T. humilis*, etc., as varieties and sub-species of "*T. virginiana* L. (U. S. A.)."

[2] On p. 272 and again on p. 274 he uses the hypothesis of "*continued self-fertilization*" to explain his results.

I. SEED PRODUCTION.

Prolonged search during the fruiting season failed to reveal a plant which was not producing seeds. No doubt such plants do exist, but none was found among the several hundred we examined. Most of the plants we examined were setting abundant seeds and many of the populations included young seedling plants.

II. VARIABILITY BETWEEN PLANTS IN WILD POPULATIONS.

The morphological consequences of vegetative and sexual reproduction are so different that a careful morphological analysis of wild populations will yield critical evidence. Such an analysis will do more than demonstrate merely the occurrence or non-occurrence of vegetative reproduction. It will make possible an evaluation of the relative importance of sexual and vegetative reproduction in maintaining the species. If vegetative reproduction is of any considerable importance its existence will be demonstrated in three different ways:

(1) The persistence of an actual organic connection between the parent plant and its vegetatively derived offspring.

(2) the frequent occurrence of morphologically indistinguishable plants which had originated vegetatively from a single individual, but in which the connection had died out or had been severed.

(3) The occasional appearance of a single, isolated individual.

These are all probably self-evident, except perhaps (3) which follows from the fact that if a species reproduces actively from seeds as well as by vegetative means, a single individual introduced into a virgin locality will soon be surrounded by seedlings, which will vary among themselves.

It would not have been surprising to have found any or all of these conditions in *Tradescantia* since all three are commonly met with among the Monocotyledons. An entire meadow is occasionally colonized by a single clone of *Iris* nor is it uncommon in that genus to find neighboring plants with no remaining evidence of an actual physical connection, between whose flowers there are no greater differences than exist on either plants. On all three of these points, however, we have evidence that vegetative reproduction is of minor importance in the tetraploid *T. reflexa*.

(1) Among the plants of *T. reflexa* which we studied there was never the slightest evidence of an organic connection between neighboring plants. Spreading by rhizomes was limited to a compact area around the parent stem.

(2) In not a single instance did we find two neighboring plants which could not be easily distinguished (see Table 4 and text fig. 2). Transplant experiments with a few of these types showed

Figure 2. A belt transect of eight two-meter quadrats at Algonquin, Missouri. Each circle represents a single clone and the area is roughly that of the crown at the time of flowering. Unshaded plants bore blue flowers, diagonal lines represent blue-magenta flowers, cross-hatching magenta, and solid black represents pink. Further description of the plants in Table 4. The divisions of the scale represent five feet.

that these individual differences were largely inherent and persisted under cultivation.

(3) We never found an isolated clone of *T. reflexa*. In every case if there was one plant there were from a dozen to several thousand other plants nearby. Although a clone of *T. reflexa* will persist for years under cultivation, gradually increasing in size, the largest we found in nature had a crown under three feet in diameter, and the crowns of the majority of wild plants are less than six inches across. As a matter of fact, the diploid species *T. bracteata* is more vegetatively vigorous than its tetraploid relative and often produces clones over two feet in diameter.

A DETAILED STUDY OF ONE COLONY OF T. REFLEXA

A typical colony of *T. reflexa* was chosen for intensive study and a part of the data collected are presented in Table 4 and figure 2. The colony occupied two or three acres along the Missouri Pacific right of way near the Algonquin suburban station in Webster Groves, Missouri. Eight two-meter quadrats were laid out in one belt transect. The individual clones were scored for height, pubescence of sepals and ovary, flower color, and number of stems.

While the variation in flower color and in pubescence was somewhat greater than we usually found, it was by no means exceptional. The variation in height of stem and size of clone was, on the other hand, less extreme than the average. The seed capsules of Tradescantia explode when ripe and discharge their seeds over a radius of a few feet. If a colony is left undisturbed there would soon be a tendency for seedlings to show greater resemblances to neighboring plants than to the colony as a whole. There is some circumstantial evidence from this colony and from other colonies that in this way seedlings tend to grow up around a prolific mother plant and form small "neighborhoods" in which adjacent plants resemble one another more closely than they do the colony at large. It will be seen from figure 2 that plants of different colors are not distributed at random. This was even more evident when the whole colony was examined. Although no two neighboring plants were identical there was often a "family resemblance" between them, and pink and magenta flowered plants tended to occur in groups.

A SURVEY OF SOUTHWESTERN TRADESCANTIAS

In addition to the material which we collected personally we were enabled through the kindness of Dr. B. C. Tharp of the University of Texas and Dr. D. W. Moore of the University of Arkansas to make a preliminary survey of the Tradescantias from those regions.

TABLE 4

Clone	Height of Stem	Pubescence on Sepals	Pubescence on Ovary	Flower color (approximate)	No. of stems
AA	short	tufted at apex	glabrous	medium magenta	
AB	short	scattered	glabrous	medium magenta	
AC	short	scattered	a few hairs at base of style	medium magenta	
AD	medium	tuft at apex	glabrous	medium magenta	Unless Otherwise Indicated there was One Stem per Clone
AE	medium	scattered	hairs at base of style	medium blue	
AF	short	scattered	glabrous	blue	
AG	medium	scattered	glabrous	blue	
AH	medium	scattered	hairs at base of style	magenta	
AI	medium	tuft at apex	glabrous	blue	
AJ	medium	lightly scattered	glabrous	blue	
AK	medium	lightly scattered	glabrous	medium magenta	
AL	medium	lightly scattered	glabrous	dark blue	
AM	medium	lightly scattered	glabrous	dark blue	
AN	medium	lightly scattered	glabrous	dark blue	
AO	medium	lightly scattered	glabrous	dark blue	
AP	medium	lightly scattered	glabrous	medium magenta	
AQ	medium	lightly scattered	glabrous	blue	
AR	medium	lightly scattered	glabrous	medium magenta	
AS	short	lightly scattered	glabrous	blue	
AT	medium	lightly scattered	glabrous	medium magenta	
AU	tall	tuft at apex	glabrous	blue	
AV	medium	tuft at apex	glabrous	medium magenta	
AW	medium	tuft at apex	glabrous	blue	
AX	medium	tuft at apex	glabrous	medium magenta	
AY	short	scattered	glabrous	medium magenta	
AZ	tall	scattered	glabrous	medium magenta	three stems
BA	tall	tuft at apex	glabrous	blue	
BB	medium	tuft at apex	glabrous	blue	
BC	short	scattered	glabrous	blue	
BD	short	scattered	glabrous	medium magenta	
BE	past blooming				
BF	medium	scattered	glabrous	medium magenta	
BG	medium	tuft at apex	glabrous	medium magenta	
BH	tall	tuft at apex	glabrous	medium magenta	
BI	medium	lightly scattered	hairs at base of style	light blue	
BJ	medium	tuft at apex	hairs at base of style	medium magenta	
BK	medium	tuft at apex	glabrous	medium blue	
BL	short	scattered	glabrous	blue	
BM	medium	scattered	glabrous	medium magenta	
BN	medium	scattered	glabrous	medium magenta	
BO	medium	scattered	glabrous	medium magenta	
BP	medium	scattered	glabrous	blue	
BQ	medium	scattered	glabrous	blue	
BR	medium	tuft at apex	glabrous	magenta	
BS	medium	tuft at apex	glabrous	magenta	
BT	medium	tuft at apex	glabrous	medium magenta	
BU	short	scattered	glabrous	medium magenta	
BV	medium	scattered	glabrous	medium magenta	two stems
BW	medium	scattered	glabrous	blue	
BX	medium	tuft at apex	glabrous	magenta	two stems
BY	medium		through blooming		
BZ	tall	scattered	glabrous	blue magenta	
CA			Seedling		
CB	tall	scattered	glabrous	madium magenta	

TABLE 4—Continued

Clone	Height of Stem	Pubescence on Sepals	Pubescence on Ovary	Flower color (approximate)	No. of stems
CC	tall	scattered	glabrous	dark blue	four stems
CD	medium	scattered	glabrous	dark blue magenta	
CE	medium	tuft at apex	glabrous	medium magenta	
CF	short	tuft at apex	hairs at base of style	pink	
CG	medium	tuft at apex	glabrous	blue	
CH	medium	scattered	glabrous	dark blue	
CI	tall	tuft at apex	glabrous	dark blue	two stems
CJ	tall	tuft at apex	glabrous	dark blue	two stems
CK	medium	scattered	glabrous	light blue	
CL	tall	tuft at apex	glabrous	dark blue magenta	three stems
CM	short	tuft at apex	glabrous	blue	
CN	short	tuft at apex	glabrous	dark blue magenta	two stems
CO	tall	tuft at apex	glabrous	dark blue	
CP	medium	scattered	glabrous	dark blue	
CQ	tall	scattered	glabrous	dark blue	three stems
CR	medium	tuft at apex	glabrous	dark blue	seven stems
CS	medium	scattered	glabrous	blue	four stems
CT	short	scattered	glabrous	magenta	
CU		Seedling			
CV	short	scattered	glabrous	blue	
CW	medium	tuft at apex	glabrous	blue	
CX	short	tuft at apex	glabrous	magenta	
CY	medium	scattered	glabrous	blue	seven stems
CZ	medium	scattered	glabrous	blue	
DA	medium	scattered	glabrous	dark magenta	
DB	short	tuft at apex	glabrous	light blue	
DC	tall	tuft at apex	glabrous	blue	
DD	tall	tuft at apex	glabrous	medium blue	large clone
DE	medium	scattered	glabrous	blue	
DF	short	scattered	glabrous	blue magenta	
DG	short	tuft at apex	glabrous	blue magenta	
DH	short	tuft at apex	glabrous	blue magenta	
DI	tall	scattered	glabrous	light blue	large clone
DJ					
DK	medium	scattered	glabrous	blue magenta	
DL	medium	scattered	glabrous	dark blue	large clone
DM	tall	tuft at apex	glabrous	light blue	large clone
DN	tall	tuft at apex	glabrous	dark blue	five stems
DO	medium	scattered	glabrous	magenta blue	four stems
DP	tall	scattered	glabrous	blue	large clone
DQ	medium	tuft at apex	glabrous	blue	
DR	medium	scattered	glabrous	blue	
DS	medium	scattered	glabrous	magenta	
DT	tall	scattered	glabrous	medium blue	seven stems
DU	medium	scattered	glabrous	light blue	

The material was forwarded just before it came into bud and was grown in the greenhouse, where material for smears was obtained. The following species were examined: (with the exception of *T. texana* the determinations are those made by Dr. Tharp.)

	PMC	Pollen Mitosis
T. humilis		
plant A	n = 6	—
plant B	n = 6 + f	n = 6 + f
T. edwardsiana[1]	—	n = 6

[1] *Tradescantia edwardsiana* Tharp in Rhodora, XXXIV. 57, fig. 1 (1932).

	PMC	Pollen Mitosis
T. hirsuticaulis	—	n = 6
T. texana	n = 6	n = 6
T. gigantea		
plant X	n = 6 + f	n = 6 + f
plant Y	n = 6	n = 6
T. occidentalis	—	n = 6
T. sp. (reflexa ?) from Texas	—	n = 6
T. sp. (reflexa ?) from Arkansas	—	n = 6

It will be noticed that whereas two of the species in the St. Louis region were tetraploids, all of the material from the southwest was diploid. One of the species from Texas and all of the plants from Arkansas were very similar to *T. reflexa* as it occurs in Missouri; just how similar could not be determined since the southern material was forced into bloom under abnormal conditions. If these plants do not belong to *T. reflexa*, they must certainly form a very closely related species. Since the Missouri and other northern material of *T. reflexa* was all tetraploid it is therefore quite possible that polyploidy is intraspecific in *Tradescantia* and that diploid and tetraploid races may occur within the same species.

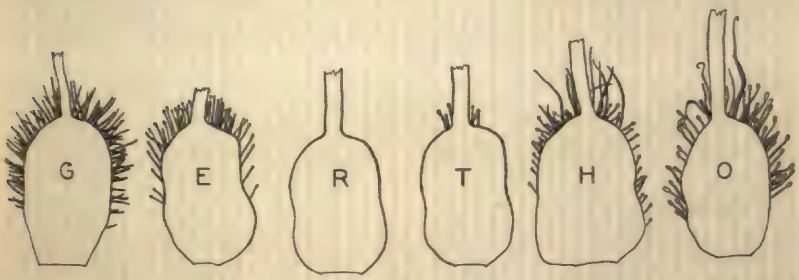

Figure 3. Ovaries of six species of *Tradescantia* from the neighborhood of Austin, Texas. Drawn, greatly enlarged, with camera lucida. From left to right: G; *T. gigantea;* E; *T. edwardsiana;* R; *T. reflexa;* T, *T. texana;* H, *T. hirsuticaulis;* O, *T. occidentalis.*

It is particularly interesting that the tetraploid Tradescantias should be more northerly than the diploids. Sax (1931) has reported in the closely related genus *Rhoeo*, the artificial production of tetraploids by exposure to low temperatures. A similar geographical position for tetraploid races and species to the north of their diploid relatives has been reported for a number of genera. Hagerup (1928) collected six such cases in the Bicornes alone and has recently summarized the evidence on polyploid geographical races (1932). It is particularly interesting that Mangelsdorf and Reeves (1931) working with another American monocot of tropical affiliations (*Tripsacum dactyloides*) have found that the plants collected in Texas are diploids while those from the north and east are tetraploids.

It may be well in passing to point out that the differences between the seven diploid species from Texas are quite as great, on the whole, as are those between the three Missouri species. Polyploidy here, as elsewhere, has introduced complexity into inter-specific relationships, but species differentiation has taken place to an even greater extent in regions where polyploidy was absent.

Table 5 summarizes the outstanding differences between these species. Camera lucida outlines of their ovaries are shown in figure 3. While instances of inter-specific hybridization are not unknown, most of these Texas species are kept apart by habitat differences and maintain themselves as recognizable units over a wide area.

TABLE 5—A TABULAR COMPARISON OF SPECIES DIFFERENCES IN TEXAS AND MISSOURI

Species	Stem	Floral leaves	Pubescence on		
			Leaves	Sepals	Ovary
Texas species:					
T. texana	short, weak branched	long, equal	long, villous	dense, glandular	a few glandular hairs at top
T. gigantea	tall	short, subequal, densely pilose	glabrous	dense, non-glandular	very dense, non-glandular
T. hirsuticaulis	tall	short, unequal	hirsute	sub-glandular	glandular and non-glandular
T. humilis	short	unequal	hirsute	glandular	dense, glandular
T. occidentalis	slender	slender	glabrous	scattered glandular	glandular and non-glandular
T. sp. (reflexa ?)	medium	long, unequal	glabrous	glabrous except for tuft at apex	glabrous
Missouri species:					
T. reflexa	medium to tall	long, unequal	glabrous	glabrous except for tuft	glabrous
T. bracteata	short	very long, subequal	scattered, glandular	glandular	dense, glandular
T. pilosa	tall zig-zag	sub-equal	scattered, pilose	glandular pilose	scattered, glandular

CONCLUSIONS

It should be remembered that the following conclusions are little more than working hypotheses and that they are put forward tentatively at the end of our first year of intensive work. In beginning this study we had as our objectives (I) the description of the species of *Tradescantia* as they occur in nature and (II) the evaluation of the evolutionary processes which are taking place in them at the present time.

I. As regards the description of these species and their separation and classification we feel that they are a difficult group but by no means an impossible one. Their inter-specific relationships are not nearly so intricate as are those of such genera as *Rubus* and *Crataegus*, for instance. In this connection we have found the pubescence on the ovary a particularly useful character because it varies so little within species. A colony of Tradescantias may vary strikingly in size and general aspect from plant to plant and yet the pubescence on the ovary will be the same throughout the colony. The pubescence also varies widely from species to species. It may be dense, or sparse, or restricted to one part of the ovary, or completely wanting. The hairs may be long or short, and glandular or non-glandular. Used in connection with other characters it is very helpful in working out specific relationships.

II. In evaluating the evolutionary processes which are taking place at the present time, we have evidence on three, fragmentation, polyploidy and hybridization.

FRAGMENTATION.

In every species in which we were able to examine a number of different plants, we found individuals with supernumerary fragment chromosomes. That is, in addition to the normal chromosome complement for the species, these individuals had one or two fragment chromosomes, much smaller than the rest (Plate 45, figs. A, K). In at least two cases these fragments paired regularly at the reduction division and were distributed to all the germ cells. We found fragments occurring with roughly the same frequency in all the species which we investigated. If, as seems probable, they affect the external morphology of those plants which bear them, we have here a unique case in which one of the causes of variation within species is not itself effective in forming new species. Had it been so we should have found entire species or races which were characterized by the possession of supernumerary chromosomes.

POLYPLOIDY.

In these species of *Tradescantia* polyploidy is apparently intraspecific, with consequent division of those species possessing it into diploid and tetraploid races. It apparently allows a northern extension of the range in those species in which it has occurred. It increases manyfold the variation between individual plants. Its "blurring" effect upon variation in flower color can actually be demonstrated and a similar effect upon morphological characters is inferred from the peculiar variability of the tetraploid species, *T. reflexa* and *T. virginiana*. In the section of the genus which we have

studied, polyploidy does not occur at the center of specific diversity but is instead characteristic of the northern periphery of the genus. It must therefore be of relatively minor importance as a factor in originating new species though it multiplies the complexity of *inter*-specific and *intra*-specific relationships.

HYBRIDIZATION.

Although this undoubtedly occurs we have as yet found little actual evidence for it. The colony from Hillsboro, described above, may perhaps have resulted from previous hybridization between *T. reflexa* and *T. bracteata*. An apparent example of hybridization between *T. humilis* and *T. reflexa* has just been discovered in the vicinity of Austin, Texas.

SUMMARY

Three species of *Tradescantia* are common in the region about St. Louis, Missouri, two tetraploid species *T. reflexa* and *T. pilosa*, and one diploid species, *T. bracteata*. White-flowered and pink-flowered forms are frequent in *T. bracteata* while in the two tetraploid species they are rare. Furthermore various intermediate magenta shades are common in the tetraploid *T. reflexa* but are not found in *T. bracteata*. This is shown to follow logically from the fact that *T. reflexa* is practically an auto-tetraploid.

Darlington's assumption of highly developed vegetative reproduction in tetraploid Tradescantias is found to be without any foundation in fact.

The inter-clonal variation of a single colony is presented in detail.

Seven species of *Tradescantia* from eastern Texas were found to be diploids.

The evolutionary importance of fragmentation, polyploidy, and hybridization is briefly discussed.

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Chromosomes and Ovary Hairs of Tradescantia Species

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EXPLANATION OF PLATE 45

Chromosomes of Tradescantia species. All drawn with camera lucida at bench level from temporary or permanent smears. I drawn from a plant from eastern Missouri. The others are all from plants collected in the neighborhood of Austin, Texas. In figures I and K the different levels have been drawn separately to avoid confusion.

A. *T. gigantea*. Pollen mitosis. n = 6 × f.
B. *T. texana*. Pollen mitosis. Smear slightly crushed. n = 6.
C. *T. humilis*. Pollen mitosis. n = 6.
D. *T. edwardsiana*. Pollen mitosis. n = 6.
E. *T. occidentalis*. Pollen mitosis. n = 6.
F. *T. sp.* (*reflexa* ?). Pollen mitosis. n = 6.
G. *T. hirsuticaulis*. Pollen mitosis. n = 6.
H. *T. humilis*. P M C. 6 bivalents.
I. *T. reflexa*. P M C. 6 bivalents and 3 quadrivalents.
J. *T. humilis*. P M C. Metaphase showing "insertion points."
K. *T. gigantea*. P M C. 6 bivalents and one pair of fragment chromosomes. Two of the bivalents have been drawn at one side for clearness.

Below. Ovary hairs, drawn greatly enlarged with camera lucida. Left, *T. gigantea* from Austin, Texas; center, *T. bracteata* from Portage des Sioux, Missouri; right, *T. pilosa* from Hermann, Missouri.

A COMPARATIVE STUDY OF THREE PHYTOPHTHORA DISEASES OF LILAC AND OF THEIR PATHOGENS

KENNETH S. CHESTER

With a diagram and plates 46 and 47

I. INTRODUCTION

A SERIOUS DISEASE of Lilacs caused by *Phytophthora Syringae* Kleb. has been recognized for many years in European lilac plantings. Very recently a second lilac disease attributed to *Phytophthora cactorum* (L. & C.) Schroet. has been found in America. A third lilac disease due to a distinct form of *Phytophthora* has been under observation at the Arnold Arboretum for several years. The present paper beside first reporting and describing the disease last named and its causal organism also reports a comparative study of the three Phytophthora diseases of Lilac with respect to the symptoms, etiology, and control of the diseases in question.

II. HISTORICAL

The first report of a Phytophthora disease of Lilac was that of Berkeley in 1881 (4) in which was described under the name *Ovularia Syringae* Berk. a fungus comparable to *Phytophthora infestans* (Mont.) de Bary which caused large brown patches on lilac leaves. Berkeley observed the production of conidia through the stomata and suggested that the conidia might germinate by means of zoospores. The following year Smith (31) first saw the oospores of Berkeley's fungus and described them. The germination of the conidia of Berkeley's fungus by means of zoospores was observed by A. S. Wilson in 1886 (33). Nine years later in 1905 (16) Klebahn published a short account of a disease of Lilac caused by what was in all probability the same fungus as that of Berkeley. The identity of Klebahn's fungus and that of Berkeley was not recognized, however, and Klebahn's disease was attributed to a new species and genus of fungus, *Phloeophthora Syringae* Kleb. According to Klebahn's observations the disease was seated in the cortex of mature lilac branches, was manifested by a browning and death of the cortex, and was apparently not related to any leaf disease. Klebahn succeeded in obtaining pure cultures of the fungus and in producing typical lesions on artificially inoculated plants. Although the sexual structures were seen, there was no apparent production of conidia, which latter fact, together with the location of the disease in the cortex of woody stems, led to the assumption of a new genus.

The following year Klebahn continued his studies (17) and brought out the relation of the disease to the abnormal environmental conditions of the lilac forcing industry. A much more extended account of the same disease is contained in a later work by the same author in 1909 (18), reviewed by Hasselbring in 1910 (13), in which he finally observed the conidia and recognized the true nature of the fungus. The name was accordingly changed to *Phytophthora Syringae* (Kleb.) Kleb. In this longer account Klebahn reported detailed investigations of the symptoms produced on stored and forced Lilacs, the morphology and biology of the fungus, the proof of the parasitism of *Phytophthora Syringae*, and the control measures which had been found to be effective in reducing the disease. In addition to infection experiments with Lilacs, the author also found the fungus to be capable of parasitism of a variety of other host plants. Klebahn's observations showed the disease to be present in 1909 in Hamburg and Cuxhaven, whence he believed it had been introduced from France. Later in 1909 Lustner (24) also reported it from Hohenheim and Frankfurt am Main. In 1910 Himmelbaur (15) repeated Klebahn's studies of *Phytophthora Syringae* and confirmed the latter in finding *P. Syringae* distinct from any previously reported species of *Phytophthora*.

By 1913 the fungus had spread to Holland according to the report of Schoevers (29) and was there likewise found to be causing a serious disease of cultivated lilac plants. The following year G. W. Wilson studied *P. Syringae* from the taxonomic standpoint (34), and beside confirming the earlier descriptions of the fungus the author was the first to point out the probable identity of Klebahn's fungus with that of Berkeley's. The name *Phytophthora Syringae* (Kleb.) Kleb., however, is retained. In 1918 Arnaud (1, 2) reported the appearance of the disease in France, where it was causing minor injury in a hedge of Lilac. Here for the first time the conidiophores of *Phytophthora Syringae* were observed occurring in nature on infected Lilacs.

Up to 1922 the disease had been reported from England, Germany France, and Holland. In that year Lafferty and Pethybridge (19) reported an isolation of *Phytophthora Syringae* from rotted apple fruit in Ireland. Specimens of lilac leaves probably injured by *P. Syringae* had also been received by the same authors. In the paper in question the authors reviewed the morphology of the sexual organs of *P. Syringae* and reported for the first time the presence of both amphigynous and paragynous antheridia within the species.

Phytophthora Syringae was shown to be capable of saprophytic life in the soil by de Bruyn in 1922 (5). Two years later Miss de

Bruyn published a continuation of her studies (6, 7) in which were reported an extensive series of infection experiments on Lilac. In the latter papers she found that the disease occurred in greatest destructiveness in those seasons in which there was abnormal rainfall in August or September. Infection was found to take place in the winter months, from December till April in the cortex, and from October till February in the buds. Hand picking of the leaves as a control measure was suggested, but in a later paper (8) the author found that hand picking of the leaves was so injurious to the blossoms as to eliminate it as a control measure.

The only record of *Phytophthora Syringae* in America is that of Hedges in 1929 (14). Miss Hedges found a fungus believed to be *P. Syringae* fruiting on several blighted young lilac shoots in Washington. The lesions had the appearance of those due to fire blight (*Bacterium Syringae*), and the attack was severe. Since the lesions described were on young shoots examined in May, it is possible that the *Phytophthora* found was one of the other two species here considered, since *P. Syringae* normally does not primarily attach the succulent tissues of lilac.

Phytophthora cactorum (L. & C.) Schroet., originally described as *Peronospora cactorum* by Lebert and Cohn in 1870 (20) and since investigated by many workers, is known to parasitize a great variety of host plants. On Lilac, however, it has been recognized only recently. In 1929 R. P. White described a disease of *Rhododendron* and Lilac from New Jersey, with which was associated this species of *Phytophthora* (35). Cross infection experiments proved that the same fungus was responsible for the disease in both hosts. On Lilac the disease takes the form of a dying-back of suckers and of leaf infections. Production of conidia was observed on the Lilac. As control measures for Lilacs, White suggested generous spacing of the plants, removal of dead wood, and use of a dormant spray of lime-sulphur together with summer applications of Bordeaux mixture.

With regard to the third type of *Phytophthora* causing disease in Lilac, no record has heretofore appeared in the literature.

In addition to the primarily pathological literature dealing with the lilac Phytophthoras, a number of purely mycological papers have dealt with *P. Syringae* and *P. cactorum*. An attempt will not be made to go into the taxonomy of these species at the present, but it may merely be said in passing that the two species are considered perfectly distinct by all of the leading students of the genus (G. W. Wilson, 1914, 34; Rosenbaum, 1917, 26; Leonian, 1925, 21; Tucker, 1931, 32).

III. MATERIALS AND METHODS

The cultures of *Phytophthora* employed in the present study were obtained from the following sources: (a) a culture of *Phytophthora Syringae* isolated by Miss de Bruyn from Lilac in Holland and obtained from the Centraalbureau voor Schimmelcultures at Baarn in 1928; (b) a culture of *Phytophthora cactorum* isolated from Lilac in New Jersey by R. P. White and sent to me by Dr. White in 1929; (c) several cultures of the same organism isolated from Lilac by the writer in 1929; (d) a third distinct strain isolated from Lilac in the Arnold Arboretum by the writer in 1929 and hereafter referred to as *Phytophthora* "Type A."

Stock cultures of the various strains were maintained on potato-dextrose agar. For the production of the spore forms special techniques were necessary. None of the strains produced sporangia in appreciable amount on potato-dextrose agar. For sporangium production the technique originally devised by Klebs was employed. Tiny fragments of mycelium of active cultures were transferred to large test-tubes each containing about 20 cc. of pea decoction. After several days growth in the pea broth at room temperature the mycelial mats were transferred to sterile pond water, the sterile water being renewed frequently. Distilled water did not prove satisfactory for this purpose. Abundant production of sporangia resulted at room temperature within 24 to 48 hours after transferral to sterile water. The production of sporangia was also induced by the conventional employment of Petri's mineral solution

(.4 gm. $Ca(NO_3)_2$ + .15 gm. KH_2PO_4 + .15 gm. $MgSO_4$ + .06 gm. KCl + 1000 cc. H_2O),

although Petri's technique proved much less satisfactory than that of Klebs for the species of *Phytophthora* involved.

Oospore formation was brought about by the employment of special solid media, the requirements differing for the different strains of *Phytophthora* under consideration. *Phytophthora cactorum* readily reproduced sexually on a wide variety of solid substrata. Among these steamed corn-meal, steamed green bean pods, steamed carrot, lima bean agar, oatmeal agar, and corn-meal agar proved very favorable. *Phytophthora Syringae* produced oospores with apparent difficulty, sterile lilac leaf extract (10), steamed carrot, steamed corn-meal, and oatmeal agar in the order named yielding the most satisfactory results. *Phytophthora* "Type A" produced oospores abundantly on steamed green bean pods, lima bean agar, and corn-meal agar.

Since the morphology and the physiology of the genus *Phytoph-*

thora are subject to considerable variability according to the type of substrate employed, the reactions of the lilac Phytophthoras to various artificial media were studied in detail. The following media were used to this end:

Steamed corn-meal
Steamed green bean pods
Potato-dextrose agar
Lima bean agar
Oatmeal agar
} Prepared according to the formulas of Tucker (32).

Potato-dextrose agar (Filtrate of 200 gm. boiled potato + 25 gm. agar + 30 gm. bacto-dextrose + water to make 1000 cc.).

Malt agar (50 gm. malt extract + 25 gm. agar + water to make 1000 cc.).

Prune agar (50 gm. dried prunes + 25 gm. agar + water to make 1000 cc.).

Pea broth (Filtrate from 50 gm. dried split peas boiled until soft + water to make 1000 cc.

Steamed carrot cylinders.

In addition to the media indicated above, corn-meal agar with the addition of certain stains was employed in a brief study of the penetration of dyes *in vivo*.

The observations of the Phytophthora diseases in nature and the study of the physiology, morphology, and taxonomy of the fungi involved were supplemented by an investigation of the pathology of the various strains of *Phytophthora*. For this purpose several series of inoculation experiments were performed in which the strains of *Phytophthora* under consideration were inoculated into a variety of Oleaceous plants. Such inoculations were of various form, consisting of insertions of mycelium into injured leaf and stem tissues, placing of mycelium upon unbroken plant parts, and finally permitting suspensions of freshly liberated zoospores to come into contact with the plant tissues. The inoculated plants were retained in an Arnold Arboretum research greenhouse under conditions favorable for their growth, and the inoculations were protected in the conventional manner.

Finally, all of the available literature pertaining to the Phytophthora diseases of the Lilac was carefully assembled and compiled. The bibliography at the end of this paper accordingly contains a virtually complete list of the references to scientific studies dealing with one or another phase of the problem of Phytophthora disease in Lilacs.

IV. COMPARATIVE STUDY OF THE SPECIES OF PHYTOPHTHORA PARASITIZING LILAC

As a preliminary to a correct diagnosis of the Phytophthora diseases of Lilac and to a correct determination of the rôle played by the fungi involved in causing disease, a study of the comparative mycology of the fungi was essential. Such a study has been in progress and the experimental results and interpretations will be the subject for consideration in the present section. For convenience the experimental findings are grouped under the headings of physiology, morphology, and systematics.

A. PHYSIOLOGY

The genus *Phytophthora* has long offered to systematists a difficult problem. The morphological characters by which species of fungi are separated must necessarily be relatively invariable within the species in order that the specific differences may be determined with accuracy. Where clear cut morphological differences are lacking, as in the bacterial genera, the systematist is forced to turn to the more striking physiological characters as bases for specific distinction. The taxonomic studies of *Phytophthora*, first based upon what were believed to be sharp morphological criteria, have undergone a gradual evolution from purely morphological systems to those almost purely physiological. The reason for such an evolution in approach has been that many of the morphological characters formerly assumed to be constant within a species have since proved to be capable of wide variation according to the physiological environment. Thus the position of the antheridium relative to the oogonium was at one time felt to be a constant character in *Phytophthora* species. The work of Lafferty and Pethybridge (19) however has shown that in many species of *Phytophthora* both amphigynous and paragynous antheridia occur, although there is a tendency in a given species to form the great majority of the antheridia in one or the other manner. The size of the reproductive organs, again a character which is usually dependable in the fungi, is susceptible to such wide variation in *Phytophthora* that the only findings yielding results at all satisfactory are those based on extensive biometric studies. Other characters of the species such as method of conidial germination, method of zoospore germination, mycelial characters, and sexuality likewise exhibit high degrees of variability within a given species. Accordingly any mycological study such as the present one must necessarily be concerned both with physiological and morphological characters. Among the physiological criteria which may effectively be applied to *Phytophthora* are the rate and

type of growth upon various artificial media, the production of fructifications upon various media, and the relationship of temperature and pH to rate of growth. Accordingly these various physiological factors in relation to the lilac Phytophthoras will be discussed at this point.

RATE AND TYPE OF GROWTH ON VARIOUS MEDIA. During the three years in which the lilac Phytophthoras have been a subject of study in this laboratory they have been grown on a wide variety of nutrient substrata. Freshly-made media were always employed, made according to the formulae given in the preceding section. For the preparations of fresh vegetable products small wide-mouthed vaseline bottles were used as receptacles, while for the other media both culture tubes and Petri dish cultures were employed. All of the cultures indicated below were grown at a room temperature of 21° C. The results of these experiments are indicated in the table on pages 239–240. The terms used in description of the mycelium are those of Long and Harsch (23).

It is at once apparent from a consideration of the foregoing data that there is a distinct difference in behavior toward the various media of the three strains of *Phytophthora* at hand. On the whole *Phytophthora Syringae* is more divergent from the remaining two species than the latter are from each other. This greater divergence of *P. Syringae* is particularly evident in its weaker growth on all media. On the whole *Type A* resembles *P. cactorum* in the general features of its growth reactions. On the other hand, a number of differential reactions set it apart from *P. cactorum*. Thus one finds aërial mycelium in *Type A* on oatmeal, corn-meal, malt, and prune agars, while the mycelium of the other strains is wholly appressed on these media. The aërial mycelium of *Type A* is characteristically different from that of *P. cactorum*, being longer, relatively less branched, and frequently with a silky sheen. The three strains are perhaps most strikingly differentiated on steamed carrot slants. *P. Syringae* grows much more slowly than the other strains on this substrate at room temperature, its growth being very slight during the first week while the other two strains are able to occupy the entire slant in that time. Moreover *P. Syringae* is white with much aërial mycelium at the edges of the colonies. *P. cactorum* and *Type A* are both much more sodden. *Type A* is white except as the sodden appearance makes it difficult to determine the color, while *P. cactorum* is noticeably discolored due to myriads of oospores, its color being clay-color (Ridgeway). The powdery-sodden appearance of *P. cactorum* is also readily distinguished from the silky-sodden appearance of *Type A*. Thus a consideration of the manner and extent

TABLE 1. RATE AND TYPE OF VEGETATIVE GROWTH OF THE LILAC PHYTOPHTHORAS ON VARIOUS MEDIA (21° C.)

Substrate	Days after inoculation	Phytophthora Syringae	Phytophthora cactorum	Phytophthora "Type A"
Steamed corn-meal....	6	Mycelium extensive but thin, not forming a cottony mass. Colony more than 5 cm. in diameter.	As in *P. Syringae.*	As in *P. Syringae.*
	14	Mycelium as at 6 days.	As in *P. Syringae.*	As in *P. Syringae.*
Steamed green bean pods	6	Mycelium sodden and felty, not as extensive as in the following two strains. Colony about 3 cm. diameter.	Mycelium cottony to felty, forming a distinct pellicle over water. Colony about 5 cm. diameter.	Mycelium cottony, rather thinner than the last, forming a pellicle over water. Colony about 5 cm. diameter.
	14	Mycelium as at 6 days.	Mycelium as at 6 days.	Mycelium now more cottony than in the other strains.
Lima-bean agar.....	6	Mycelium appressed, none aërial whatever. Colonies only 2.5–4.0 cm. diameter.	Mycelium cottony to felty, compact, denser and shorter than in the next. Colonies 5.0–6.5 cm. in diameter.	Mycelium almost cobwebby, thin but long except at the margin of the colony where there is a 5 mm. zone which abruptly becomes appressed. Colonies 5–6 cm. diameter.
	14	As at 6 days.	As at 6 days.	As at 6 days. Hyphae long, thin, relatively unbranched.
Oatmeal agar.....	6	Mycelium completely appressed. Very thin and difficult to see. Colonies 2–4 cm. diameter.	Mycelium completely appressed but much more easily distinguished than the last because not so thin. Colonies 7–9 cm. diameter.	Considerable aërial mycelium present, cobwebby-downy but thin and distinguished with some difficulty. Colonies 7–9 cm. diameter.
	14	As at 6 days.	As at 6 days.	Much aërial mycelium present though none on the other two strains.

TABLE 1—Continued

SUBSTRATE	DAYS AFTER INOCULATION	PHYTOPHTHORA SYRINGAE	PHYTOPHTHORA CACTORUM	PHYTOPHTHORA "TYPE A"
Corn-meal agar	6	Mycelium completely appressed, very thin and distinguished with difficulty. Colonies 2.5–3.5 cm. diameter.	Mycelium completely appressed, thin but extensive. Colonies 7–9 cm. diameter.	Mycelium much as in the last, thin, appressed, but becoming aerial (cobwebby) at the lower end of the slant. Aërial mycelium distinguished with difficulty. Colonies 7–9 cm. diameter.
	14	Mycelium as at 6 days. No aërial mycelium.	Mycelium as at 6 days. No aërial mycelium.	Aërial mycelium plainly visible.
Potato-dextrose agar	6	Mycelium sodden and slightly downy. Colonies 3 cm. diameter.	Mycelium subfelty, not at all sodden, rather compact, not long and silky as in the next. Colonies 5–6 cm. diameter.	Mycelium cottony with a silky sheen. Hyphae long. Colonies 6–8 cm. diameter.
	14	Growth moderate, sodden or slightly downy. Zonate in daylight.	Growth moderate, subfelty, azonate in daylight.	Growth strong, cottony, azonate in daylight.
Malt agar	5	Almost no growth.	Moderate, more or less sodden growth.	Extensive downy growth.
	14	Growth weak, appressed.	Growth moderate, appressed to downy.	Growth strong, appressed.
Prune agar	2	No growth.	Growth moderate, thin, appressed.	Growth strong, appressed to cobwebby.
	14	Growth very weak, appressed.	Growth moderate, appressed.	Growth strong, downy.
Steamed carrot	10	Growth very weak, downy.	Growth moderate, felty.	Growth strong, woolly.
	20	Growth weak. Downy, becoming sodden at the center.	Sodden but with such a covering of oospores as to give it a powdered appearance. Aërial mycelium downy where it appears (at center of colony only).	Sodden with none of the powdery appearance of the last. The scanty aërial mycelium is very silky.
Pea broth	3	Growth weak. Colonies .5 cm. diameter.	Growth strong. Colonies about 2.5 cm. diameter.	Growth strong. Colonies about 2.5 cm. diameter.

of growth upon various media offers evidence as to the existence of three distinct strains of *Phytophthora* parasitizing Lilac.

PRODUCTION OF FRUCTIFICATIONS ON VARIOUS MEDIA. A second type of physiological evidence is yielded by a study of the ability of *Phytophthora* to produce asexual and sexual reproductive organs on various media. Such a study has been carried on with reference to the lilac Phytophthoras and the results are summarized in Table 2 on page 242. The cultures were all made in the conventional manner, the normal pH of the cultures was not altered, and the cultures were all grown at 21° C except as otherwise indicated. In the section entitled "Klebs' technique" the fungi were grown for four or five days in sterile pea broth and then transferred to sterile pond water, the water being changed twice daily.

The data in Table 2 again reveal the striking difference between *P. Syringae* and the other two strains, although the latter two behave in a rather similar fashion with regard to the production of fructifications. Oogonia are apparently formed with some difficulty in *P. Syringae* and are absent on a number of media on which the other two fungi produce them in abundance. At the other extreme is *P. cactorum* which produces oogonia on many media in surprising numbers. For example it was seen in temperature experiments that *P. cactorum* will cover a Petri dish of corn-meal agar with a profusion of oospores in 4 days at 25° C. *Type A* behaves in an intermediate manner, forming numerous oospores on a variety of media but never to quite the same extent as *P. cactorum*. Except by the employment of Klebs' principle of suddenly removing the food supply, the production of sporangia is very limited in all the strains. None have ever been observed in artificial cultures of *P. Syringae* except as grown by the Klebs and Petri techniques. Frequently the sporangia formed in artificial culture are very irregular or abortive in form, being non-functional in the form of moniliform swellings on the hyphae, functional but bi-papillate, greatly elongated or asymmetric, etc. From the data presented one may conclude that with respect to the character of fructification on various media, *P. Syringae* is perfectly distinct from the other strains, while the latter, although resembling each other in the main do differ significantly in a number of features.

RATE OF GROWTH AT DIFFERENT TEMPERATURES ON THE SAME MEDIUM. A third physiological factor of value in differentiating species and of great importance in the economic considerations of Phytophthora diseases is temperature. Differential growth according to temperature has been seen to be of such value in species diagnosis that it ranks among the most useful characters on which

TABLE 2. PRODUCTION OF REPRODUCTIVE ORGANS BY THE LILAC PHYTOPHTHORAS ON VARIOUS MEDIA

Medium	Days after transfer	P. syringae		P. cactorum		Phytophthora Type A	
		Sporangia	Oogonia	Sporangia	Oogonia	Sporangia	Oogonia
Steamed corn-meal.....	14	None	Frequent	None	Very abundant	None	Present, not abundant
Steamed bean-pods	14	None	None	Infrequent	Very abundant	None	Abundant
Potato-dextrose agar.....	14	None	None	Frequent	Fairly abundant	Very infrequent	Present, not abundant
Lima-bean agar.....	14	None	None	Numerous	Abundant	None	Abundant
Oatmeal agar.....	14	None	Present, not numerous	None	Numerous	None	Abundant
Corn-meal agar.....	14	None	Very infrequent	Not infrequent	Numerous	None	Numerous
Klebs' technique (21° C.)	1	None	None	None	Abundant	None	None
	2	Present	None	Numerous	Abundant	Numerous	None
	3	Present	None	Numerous	Abundant	Numerous	None
	4	Numerous	None	Numerous	Abundant	Numerous	None
Klebs' technique (8° C.)	1			None	None	None	None
	2			None	None	None	None
	3			Present	None	None	None
	4			Present	None	Present	None
Petri's mineral solution. From culture on:							
A. Corn-meal agar	5	Present, not abundant		Present, not abundant		Absent	
B. Potato-dex. agar.....	5	Absent		Infrequent		Infrequent	
C. Lima-bean agar	5	Very infrequent		Very infrequent		Infrequent	

recent Phytophthora keys are based, Hence it was thought desirable briefly to investigate the behavior of the Phytophthora strains under consideration at different temperatures. It proved practicable to work only with the temperatures above 21° C, but since *P. Syringae* is apparently the only strain of the three at hand which vegetates extensively at the cooler temperatures and since the temperature relations of *P. Syringae* have been studied in detail by previous workers, the data at hand are sufficient to indicate the pronounced differences between the three strains. The temperature study reported here was conducted with the fungi growing on homogeneous lots of corn-meal agar in constant temperature chambers with a temperature variation of no more than .5° C. Thirty plates of each fungus were used at each temperature. The results may be briefly summarized as follows.

At 29° C. none of the lilac strains of *Phytophthora* made appreciable growth. At 27° C. *P. Syringae* failed to grow as did most of the cultures of *Type A* and *P. cactorum*, although a few scattered cultures of each of the latter two strains showed a very limited growth. At 25° C. *P. Syringae* failed to grow, but *Type A* and *P. cactorum* grew very extensively, the colonies being from 75 to 90 mm. in diameter after 96 hours. Numerous oospores were present in the cultures of these latter strains after 96 hours. This temperature appears to be very near the optimum for both *Type A* and *P. cactorum*, as the growth is far more extensive at 25° C. than at room temperature. The upper limit of growth for *P. Syringae* is approximately 23° C., and the optimum, according to my own observations and to Tucker's more critical studies (32), is about 20° C. Thus a clear-cut distinction according to temperature requirements exists between *P. Syringae* and the other lilac strains of *Phytophthora*. *P. Syringae* grows best at 20° C., a temperature at which the growth of *Type A* and *P. cactorum* is only indifferent, while at 25° C., the optimum temperature for both *Type A* and *P. cactorum*, the growth of *P. Syringae* is wholly inhibited. Apparently the lilac strain of *P. cactorum* is somewhat less resistant to heat than the strains of *P. cactorum* studied by Tucker, all of which vegetated at least to 27.5° C. and some to 30° C. The practical bearing of temperature requirements of the lilac Phytophthoras will be considered later in relation to their pathology.

Relation of growth to hydrogen ion concentration. A fourth physiological characteristic useful in distinguishing Phytophthora species is the relation to hydrogen ion concentration. In order to investigate this matter an experiment was devised in which the fungi were permitted to vegetate in liquid media of varying hydro-

gen ion concentrations. Pea broth was selected as the medium to be used, since all three strains of *Phytophthora* from Lilac grow well in this decoction. A single large flask of pea broth was filtered and then divided into 16 equal portions. One portion was retained without altering the normal pH, which was found to be 6.5. The other portions were titrated with decinormal HCl and KOH to a series of pH values extending from 2.5 to 10.0 at .5 pH intervals. The pH determinations were made colorimetrically by the use of Clark's indicators. Each portion was now divided into three equal samples of 15–20 cc. each, the samples being placed in 6 x 1″ test tubes. The 45 tubes were then autoclaved and finally all the tubes of each complete series of pH values were inoculated with *P. Syringae*, *P. cactorum*, and *P. Type A* respectively. The fungi were permitted to develop for 5 days at room temperature at the end of which time the amounts of growth were compared. The results are given in the following table:

	pH OF MEDIUM:															
	2.5	*3.0*	*3.5*	*4.0*	*4.5*	*5.0*	*5.5*	*6.0*	*6.5*	*7.0*	*7.5*	*8.0*	*8.5*	*9.0*	*9.5*	*10.0*
P. Syringae	0	0	3	4	4	4	4	4	4	3	1	0	0	0	0	0
P. cactorum	0	2	3	4	4	4	4	4	4	4	4	4	4	2	2	2
P. Type A	0	2	3	4	4	4	4	4	4	3	3	3	3	2	2	0

(KEY: 0—No growth; 1—Very weak growth; 2—Weak growth; 3—Moderate growth; 4—Strong growth.)

The results of this experiment confirm the earlier findings in demonstrating *P. Syringae* to be markedly distinct from the other two lilac strains of *Phytophthora*. The latter two show virtually no difference, however, in their pH reactions. The extremely long pH range of all three of these strains, particularly the latter two, is worthy of note, and the high degree of toleration exhibited argues against the possibility that the pH reaction of host tissue might play a part in the immunity or susceptibility of a given host subject to these strains of Phytophthora.

In relation to the preceding experiment in hydrogen ion control, an experiment was also performed in which was investigated the ability of certain dyes to penetrate the living *Phytophthora* cell. The experiment took the following form. A litre of clear corn-meal agar was prepared in the customary fashion. When liquid this was divided into a number of portions, to which portions were added the following stains in concentration of 6–10 drops of 1% stain solution per 50 cc. of agar: acid fuchsin, phenol red, methyl red, cresol red, and neutral red. A portion without stain was retained as a control. Samples of each portion were then poured into a number of sterile Petri dishes and inoculated with the three lilac strains of *Phytoph-*

thora. As certain of the stains used are pH indicators (phenol red, cresol red), the variations in pH during growth could be read directly. The original pH of the agar was 6.4. After 14 days *P. cactorum* and *Type A* had raised this to 7.4 in the areas occupied by mycelium, although *P. Syringae* had not changed the original pH of the agar. Methyl red appeared to have a repressing or toxic effect on *P. cactorum* and on *Type A*, but not on *P. Syringae*. On the other hand, neutral red exerted such an effect upon *P. Syringae* but not on the other two strains. None of the other stains appeared to affect the development of the mycelium or oospores.

All of the dyes used stained the oospore walls of *P. cactorum* and *Type A* brilliantly. (No oospores were formed in *P. Syringae*.) These were the only structures stained *in vivo* with phenol red, cresol red, methyl red, or acid fuchsin. In order to be certain of the presence or absence of vital staining, the mycelium was permitted to grow out on sterile cover-glasses which were later removed and examined for the presence of dye within the hyphae. Since *Phytophthora* is coenocytic, a dye which could penetrate should be carried out into such isolated hyphal stretches and thus be easily identified. The streaming of the protoplasm meanwhile offered a check as to the living condition of the hyphae. Neutral red penetrated the cytoplasm of the fungi and accumulated in the vacuoles, and could be identified far out on the sterile cover-glasses. This staining *in vivo* was accentuated when the mycelium was placed in a mildly alkaline buffer solution as an adjunct to staining. The staining of the vacuoles by neutral red but not by methyl red demonstrates that the vacuoles in these fungi are of the type designated by Bailey as "Type B" (3).

A marked reduction of the dye occurred in all the cultures containing methyl red, although such a dye reduction was not observed in the cases of the other dyes.

The evidence from this latter experiment accordingly confirms that obtained in the preceding experiments in demonstrating the similarity of reaction of *P. cactorum* and *Type A* in contrast to the marked divergence of *P. Syringae*.

B. MORPHOLOGY

Passing from a physiological to a morphological comparison of the three Phytophthora strains from Lilac, one finds that although there are certain resemblances there are also clear-cut and constant differences which readily distinguish the three strains from one another. The morphological comparison can best be pursued by considering successively the vegetative body, the asexual reproduc-

tive structures, the sexual reproductive apparatus, and finally the abortive reproductive structures so commonly found in this group of fungi.

VEGETATIVE BODY. The mycelium of all three strains of *Phytophthora* from Lilac is typical for the genus. In all cases the hyphae are highly granular and vacuolate, irregular in diameter and branching, and for the most part non-septate except at the bases of the reproductive structures and in old hyphae. Streaming of the protoplasm is customarily observed in all the strains, particularly in actively growing cultures in the main hyphae supplying the peripheral branch systems. This streaming is rapid and in all cases takes the form of an oscillation rather than a cyclosis as in the higher plants, the period of oscillation being from one to several minutes.

In order to obtain an accurate basis for comparison of the mycelial characters of the three strains, cultures were made on cornmeal agar and examined critically after one week's growth at room temperature. The following descriptions were made from examinations of such cultures.

In *Phytophthora Syringae* the branching is monopodial with the lateral branches irregularly distributed along the main axes and typically at right angles to the latter. The laterals are frequently constricted at the point of junction with the main axes and are poorly developed with relation to the main axes. Septations are very infrequent, are curved with the direction of curvature bearing no relation to the direction of growth, and are perforate. The diameter of the hyphae is variable, usually, however, fluctuating between 3 and 7 microns. The hyphae are granular or with extended vacuoles. Streaming is frequent and rapid.

In *P. cactorum* the branching is irregularly monopodial although sometimes approaching dichotomy. The lateral branches are more highly developed than in *P. Syringae*, are typically at right angles to the main axes, and are frequently much constricted at the junctions with the main axes. The hyphae are very granular and with fewer vacuoles than in *P. Syringae*. Septations are very infrequent, being found for the most part in empty hyphae, and are curved. The diameter of the hyphae is much more variable than in *P. Syringae* although the customary limits are between 3 and 7 microns. Streaming is frequent and rapid.

In *Type A* the hyphae are much more highly branched than in either of the preceding species on this substrate. The branching is typically monopodial but often becomes nearly dichotomous. The laterals may be perpendicular to the main axes, but more frequently they leave at an angle of between 50° and 70°. The hyphae, which

are finely granular, are more delicate and more even in diameter than in *P. cactorum*, varying between 2 and 6 microns in diameter. Septations are very infrequent and as in the species preceding are curved. The lateral branches are frequently constricted at their junctions with the main axes. Streaming is frequent and rapid.

The descriptions above apply exclusively to the aërial and superficial mycelium, the submerged mycelium being frequently very abortive in appearance. In all three strains there is a tendency for the mycelium of old cultures to assume an atypical condition, and this is particularly true of *P. Syringae*, where the hyphae of old cultures are often knotty, vesicular, and highly irregular.

In connection with the experiments in vital staining reported above, an interesting reaction to food supply was observed in *Type A* and later confirmed in the other species. Sterile cover glasses had been dropped onto the surface of the agar in newly made corn-meal agar cultures. The growing mycelium coming into contact with the sterile glass surface in many cases grew out onto the latter for a distance of one or more millimeters. As each hypha grew out onto the glass it produced a fairly complex system of lateral branches. Eventually, however, the dendritic system reached such proportions that the main hypha could no longer maintain a sufficient supply of nutrients for its needs. The reaction of the branch system was as follows. First a complete septation occurred near the edge of the cover slip in the main hypha. The protoplasm of the main hypha then retreated for a distance of about 10 microns and a second septation then separated the empty hyphal stretch from the retreating protoplasm. If any side branches lay along the unoccupied stretch of hypha, these also emptied into the retreating mass. Soon the process was repeated. A second retreat followed by a second septation was observed. This process continued until there were 10 or more septations in the empty section of hypha. Meanwhile the protoplasm of the more peripheral branches of the dendritic system was likweise receding, always marking the path of retreat by successive septations. In brief the protoplasm of the whole dendritic system was becoming condensed in the center of the dendritic mass, and the protoplasm was maintaining its life at the expense of a portion of itself. The remaining protoplasm was alive and active, and presumably would continue so until it had entirely consumed itself.

Asexual reproductive structures. The morphology of the asexual reproductive organs, in particular the zoosporangia, is of prime importance in the distinction of the strains of *Phytophthora* from Lilac, because herein lies the most important difference between *Type A* and *P. cactorum*, the two strains which up to the present have been seen to differ only in minor characteristics.

In general structure the sporangia of all three of the strains are wholly typical for the genus. They arise terminally on relatively undifferentiated sporangiophores, singly or in sympodial clusters, the successive sporangiophores always arising below the base of the preceding sporangium, never passing through the empty sporangium preceding as in the group of *P. cryptogaea*. No essential differences in development of the sporangia of the three lilac strains of *Phytophthora* have been observed. However, the character of the papilla of emergence of the zoospores is markedly different in the lilac Phytophthoras. The papilla of *P. cactorum* is of the more common form in the genus, prominent, sometimes even approaching cylindrical in shape. The papillae of the other two strains, on the contrary, are flattened, inconspicuous, crescentic in vertical section. That the type of papilla is a relatively fixed character is seen in the prominence given to this character in the recent taxonomic studies of the group. The papillae of *Type A* are so wholly distinct from those of *P. cactorum* that there is no danger of confusing the two even with a cursory examination of the sporangia, and in the many conditions of sporangium production observed, the character of papilla remained constant. That there is also a difference in the chemical composition of the papillae in *Type A* and *P. cactorum* is evident from the fact that the papillae of *P. cactorum* are often either dissolved or rendered invisible in Amann's lacto-phenol preparations, while those of *Type A* remain perfectly distinct under the same conditions. The types of papillae in the three lilac strains of *Phytophthora* are illustrated in Figures 1–24 of plate 46.

The lilac strain of *P. cactorum* is also distinguished from the other two strains by the fact that the sporangia are much more likely to be deciduous. If water cultures containing quantities of the sporangia of the three lilac strains of *Phytophthora* be shaken vigorously, many of the sporangia of *P. cactorum* will become detached, while those of the other two strains do not become detached to appreciable extent. The detached sporangia of *P. cactorum* each bear a tiny stump of the conidiophore, but these stumps are so short (being no more than half as large as the papillae of the same sporangia) that they could hardly be considered pedicels. In any case there is no evidence of the presence of pedicels in *P. Syringae* or in *Type A*, a point which will be considered in the systematic discussion to follow.

The mature sporangia typically emit zoospores in the customary fashion in the three lilac strains, and no significant differences in the three strains in mode of emission or in number, structure, or behavior of the zoospores were observed.

The released zoospores swim vigorously for a period of the order of an hour or less. They then come to rest, round off, lost their flagella, and germinate shortly. The rapidity of germination and the length of the germ tubes produced are astonishing. For example in one experiment in which freshly liberated zoospores were permitted to germinate in sterile pond water, the total length of hypha resulting from typical spores after 24 hours was measured. Such measurements gave for *P. Syringae* 270 microns, 315 microns, 210 microns, 227 microns, 217 microns, etc., for *P. cactorum* 210 microns, 112 microns, 158 microns, 227 microns, 158 microns, etc., and for *Type A* 402 microns, 356 microns, 140 microns, 368 microns, 315 microns, etc. One frequently observes that in the germination of the zoospores the limited amount of protoplasm passes to the tip of the growing germ tube, so that a germinated spore would typically show an empty spore case produced out into a long germ tube, the proximal portion of which would be empty, and the distal growing portion rich in protoplasm.

Studies were made of the measurements of the sporangia, but since no significant difference was found in the three strains under consideration and since the measurements of the sporangia of any one strain vary within extremely wide limits, no attempt will be made to differentiate the three according to this character. In the majority of sporangia of all three types the length varies from 20 to 40 microns and the width from 15 to 30 microns. There is also no significant difference in the ratio of width to length, this constant averaging in all the strains between .65 and .80.

Sexual reproductive structures. The most fundamental morphological character in the separation of species of *Phytophthora* has been the type of antheridium, whether amphigynous (surrounding the oogonial stalk) or paragynous (not surrounding the oogonial stalk). Although Lafferty and Pethybridge (19) and others subsequently have shown that both amphigynous and paragynous antheridia may occur within the same species, yet all described species in which the sexual structures occur are characterized by having a distinct majority of the antheridia of one type or the other. The amphigynous type is by far the commoner in the genus, and it is very interesting to observe that the antheridia are chiefly paragynous in all of the lilac strains, although according to Tucker's conception (32) no other valid species than *P. cactorum* and *P. Syringae* possess a majority of paragynous antheridia. The antheridia of *Type A* are perfectly typical for the paragynous type and differ in no essential from those of *P. cactorum* and *P. Syringae*, as will be seen from an examination of Figures 27–30 of Plate 47. In all the

species here involved they are long persistent and are chiefly basal, only occasionally being lateral in position.

In all three strains the oogonia are broadly clavate to subspherical or spherical and usually terminal. The oospores are in all cases spherical, hyalin to light yellow, with the contents granular and variously vacuolate, and with a thick triple wall. The character of this wall appears to differ somewhat in *Type A* from the other two strains. In the latter it is smooth, while in *Type A* under some conditions it appears to be surrounded by a granular aura. The size of the oospores was investigated by employing statistical methods, as the variability is so great within a species as to require such a procedure. Measurements were made of 400 living oospores of each of the three strains, the measurements were grouped into classes, the frequencies plotted, and the constants calculated. The results are given in Text figure 1.

The following constants were derived from the data obtained:

	P. CACTORUM	TYPE A	P. SYRINGAE
Mean (in microns)	22.94 ± .06	24.97 ± .09	31.10 ± .11
Median (in microns)	22.79	24.92	31.68
Mode (in microns)	21.36	24.92	32.04

It will be seen that the measurements for *P. Syringae* are slightly greater than those found by other investigators (the mean usually being in the neighborhood of 28 microns). However, the difference between the measurements of *P. Syringae* and those of the other two strains is sufficiently great that it is considered significant in the distinction of the species. On the other hand, the difference in measurement between *Type A* and *P. cactorum* is so slight, in comparison with the variations within *P. cactorum*, that that difference is not felt to be significant for the purposes of species distinction.

Phytophthora omnivora is known to be heterothallic (22). Other species, such as *P. Cinnamomi*, *P. cryptogaea*, *P. Richardiae*, and *P. Phaseoli*, appear to be definitely homothallic (22). It was of interest, therefore, to look for any evidence as to the condition of sexuality in the lilac strains of *Phytophthora*. Such evidence was easily forthcoming, as an examination showed that in all three strains it was possible definitely to trace the origin of oogonia and antheridia from the same hyphal thread. Such a situation is figured for *Type A* and *P. cactorum* in Figures 29 and 32, 34 respectively, and has been illustrated by Klebahn for *P. Syringae* (18 p. 43, figs, 32, 33). Hence it may be maintained that all three of the strains in question are homothallic, at least customarily.

ABORTIVE REPRODUCTIVE STRUCTURES. Other types of reproductive structures than those considered above have been described

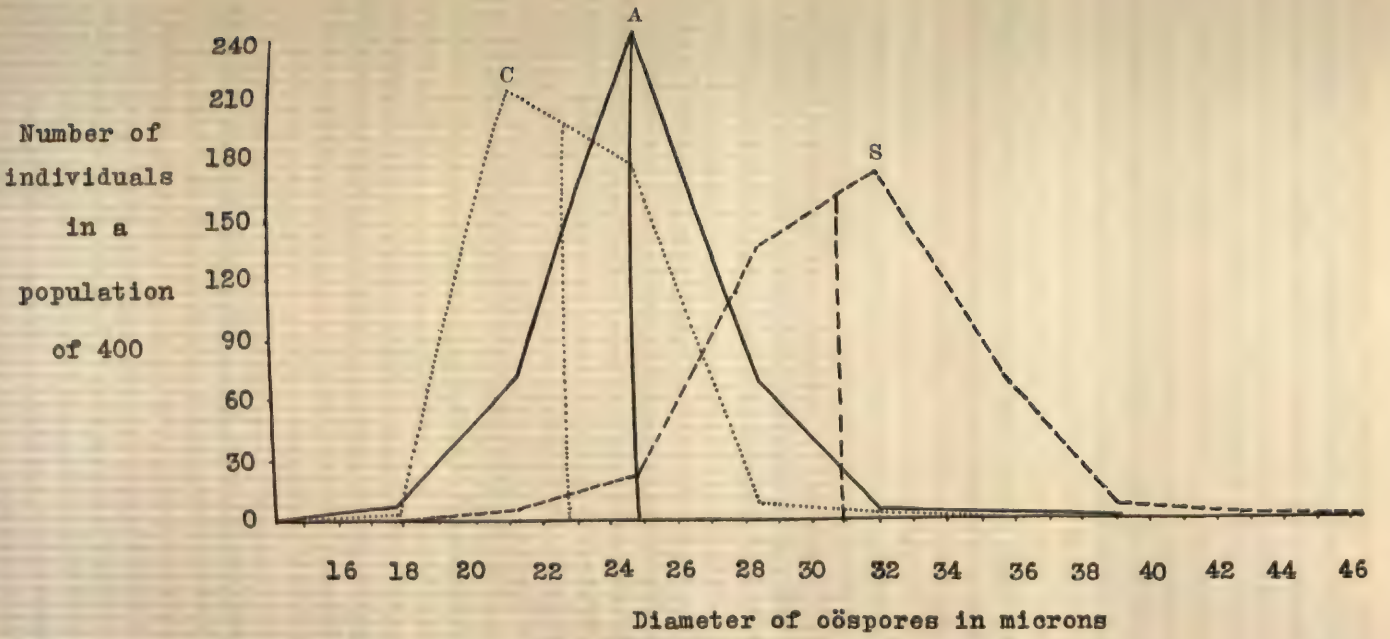

FIG. 1. OOSPORE SIZE IN THE LILAC STRAINS OF PHYTOPHTHORA

KEY: C. = P. cactorum; A = P. cactorum applanata; S = P. Syringae. The vertical lines represent the positions of the mean diameters.

in *Phytophthora*, as chlamydospores, pseudo-oospores, etc. There appears to be a certain amount of confusion as to the interpretation of these structures. In the strains of *Phytophthora* from Lilac such abortive reproductive structures have frequently been observed. Thus if one applies the Klebs technique to the fungi one finds that before the production of the great majority of sporangia, tentative attempts at sporangium-production end in an abortive fashion. The sporangia swell as in the typical fashion, but instead of maturing as sporangia a hypha continues out of the papilla region, and the sporangium becomes merely a more or less spherical dark swelling on the hypha. Frequently this is repeated several times in succession so that a chain of such swellings come to lie along the hypha. Although these might at first glance be interpreted as chlamydospores, the intermediate stages indicate that they are merely abortive sporangia formed when the conditions for sporangium-production are approached but not quite realized. This phenomenon is particularly noticeable in *P. Syringae*. At other times, particularly in old water cultures of *P. cactorum*, one frequently finds many "oospores" without antheridia. Whether these represent true oospores which have as yet failed to become fertilized, or whether they represent an abortive type of oospore or sporangium cannot readily be answered. Both the "unfertilized oospores" and the abortive sporangia, in any case, seem to be so dependent upon environment for their production and so erratic in occurrence that they are merely mentioned in passing, and no attempt will be made to use them in species distinctions.

C. SYSTEMATIC CONSIDERATIONS

With the background of comparative physiology and morphology as treated above it is now possible to orient the three lilac strains of *Phytophthora* within the genus. Since its original description *P. Syringae* has been felt to represent a well characterized and distinct species. Gäumann (12) considers it a race of *P. omnivora* de Bary, but the form of the sporangia together with other characters easily distinguish it from the *omnivora* group. The cultures of *P. Syringae* studied and reported in this paper conform in every respect to the original and to subsequent descriptions of *P. Syringae*.

Phytophthora cactorum (L. & C.) Schroet. includes a number of other species names according to the conceptions of various workers. Tucker's view of *P. cactorum* (32) includes *P. Fagi* Hartig, *P. omnivora* de Bary, *P. Pini* Leon., and its variety *Antirrhini* Sun. & Ram., and *P. Paeoniae* Coop. & Porter. Various species have been included within the concept of *P. cactorum* by Leonian and others.

No attempt will be made here to determine the species limits of *P. cactorum* in respect to the various allied species of the *cactorum-omnivora* group. Suffice it to say that all of the species so included are characterized by having the prominent type of papilla illustrated in this paper in Figures 9–16. Certainly *P. cactorum* is well distinguished from *P. Syringae*, although both typically have paragynous antheridia, by its prominent papillae and its very different power of growth and reproduction, even at temperatures at which *P. Syringae* utterly fails to make progress. The study of the cultures of *P. cactorum* considered in this paper shows the fungus to be perfectly typical to the earlier descriptions.

Passing then to the third lilac strain, *Type A*, one is confronted with the problem of ascertaining its systematic position. In the type of antheridia and in the majority of its physiological reactions it is manifestly similar to *P. cactorum*. The question then arises as to whether any description has been published of a *Phytophthora* bearing such a combination of characters as those described for *Type A*.

According to the treatment of Tucker (l. c.), the most recent thorough taxonomic treatment of the genus, *Type A* would necessarily fall within the group comprising *P. cactorum* and *P. Syringae* (with widely spreading growth on all ordinary media after 6 days at 20° C., and with predominantly paragynous antheridia). A number of species have been added to the literature since the publication of Tucker's work and these are here briefly considered.

In *Phytophthora gonapodiodes* (Peters.) Buis. (9) the secondary sporangia proliferate *through* the preceding sporangia in a fashion wholly different from that of any other *Phytophthora* species. *P. Porri* Foister, recently described on the Leek (11), is commonly characterized by apapillate sporangia and paragynous antheridia but it differs from *Type A* in the much larger oospores (32–33 microns) and proportionally much smaller antheridia. The descriptions of four species and varieties recently studied by Sideris have been made available through the kindness of Dr. Sideris (30). None of these, however, are identical with *Type A* since in *P. manoana* Sideris on *Ricinus* the sporangia are stipitate and papillate and sexual organs are absent, in *P. symmetrica* Sideris on *Ficus* the conidia usually germinate by a germ tube, and the sexual apparatus is absent, while in both *P. Meadii* var. *ananaphthora* Sideris and in *P. melongena* var. *ananaphthora* Sideris on *Ananas* the sporangia are prominently papillate and the antheridia predominantly amphigynous. A group of species from Formosa have recently been described by Sawada. Neither of the two species not included in

Tucker's treatment could be identical with *Type A* since in *P. Cyperi-rotundati* Sawada (28) the papillae are flat but the sporangia are pedicillate and the oospores are too large, averaging 30.8 microns, while in *P. Lepironiae* Sawada (= *Nozemia Lepironiae* [Saw.] Saw.) (27) the sporangia are entirely apapillate and the oospores very large, averaging 30–38 microns. *Phytophthora megasperma* Drechs. on *Althaea*, described by Drechsler in 1931 (10a), differs from Type A in the internal proliferation of the sporangiophores and in the very large size of the oospores (averaging 41.4 microns). Finally a new strain of *Phytophthora Syringae* has been very recently described by Ogilvie as causing a fruit rot of apples and pears in England and South Wales. This new strain, however, in morphology and in physiological reactions is plainly distinct from *Type A*. Thus Ogilvie records that the growth of this strain is poor or imperceptible on malt agar, bean agar, and corn agar, and that oospores are formed only on Quaker Oat agar, while it has already been pointed out that *Type A* vegetates and forms oospores profusely on these media. Ogilvie's strain also shows on potato-dextrose agar the knotty development of the mycelium so characteristic of *P. Syringae* and only rarely seen in *Type A*.

It is thus seen that *Phytophthora Type A* from Lilac differs strikingly from any described species of *Phytophthora*, while it resembles more closely *P. cactorum* than any other described species. It differs from *P. cactorum* in several respects, chief of which is the flattened nature of the sporangial papilla. It is therefore felt that *Type A* represents if not a distinct species at least a distinct variety of *P. cactorum*, and accordingly it is here so indicated. Since the structure of the papilla is the most striking differential character in comparison with *P. cactorum*, the name *Phytophthora cactorum* (L. & C.) Schroet. var. *applanata* n. var. is proposed. The diagnosis of this variety is here introduced.

Phytophthora cactorum (L. & C.) Schroet. var. **applanata**, n. var.

A typo differt sporangii papillis applanatis non prominentibus.

This variety differs from the species in the consistent presence of flattened, non-prominent sporangial papillae. Parasitic on the young growth of various horticultural varieties of *Syringa vulgaris* causing a soft dark decay. Hab. in Massachusetts, U. S. A.

V. COMPARATIVE PATHOLOGY OF THE SPECIES OF PHYTOPHTHORA PARASITIZING LILAC

Having inquired into the structure and behavior of the lilac strains of *Phytophthora* and established their identity, it now becomes necessary to consider more in detail the diseases caused by

them. The present section, accordingly, will deal with the nature of the diseases caused, reserving for the following section a treatment of the subjects of prognosis and control. The nature of the diseases of Lilac caused by *Phytophthora* species has been ascertained both by observations of the symptoms and of predisposing factors to the diseases as they occur in the field and also by infection experiments. These sources of evidence will accordingly be treated in turn. It must be stated at the outset that the disease caused by *P. Syringae* does not appear to occur in America, and accordingly the description of this disease is based upon the fairly extensive published accounts.

A. SYMPTOMS

According to Klebahn (18) the disease caused by *Phytophthora Syringae* manifests itself first by an inhibition of development of the buds of the younger shoots. The cortex of the diseased twigs is killed with the result that the bark of the diseased twigs is darker than that of healthy twigs and somewhat shrunken. Usually such killing of the cortex involves the whole circumference of the twigs. The vascular system is not affected in the earlier stages of the disease but eventually it becomes interfered with and the whole of the affected twig dies. Occasionally the disease may be limited to a single bud or part of a bud. Such symptoms become noticeable only at the time of spring development, although the fungus may be actively killing the cortex during the winter.

Miss de Bruyn has pointed out (6) that *Phytophthora Syringae* may also attack the leaves, causing irregular brown patches with lighter margins. If the *Ovularia Syringae* of Berkeley is the same fungus as *Phytophthora Syringae* (Kleb.) Kleb., as is probable, then Berkeley's description of the brown leaf infections of lilac (4) harmonizes with the findings of Miss de Bruyn. Arnaud has also observed the same type of leaf infections (1, 2). Oospoores are customarily found in the infected tissues, and in moist weather zoosporangia are also produced, the latter emerging through the stomata as in the case of *Phytophthora infestans* according to Berkeley. Finally the infection experiments carried out in connection with the study reported in the present paper indicate that *Phytophthora Syringae* is also able, under some conditions, to attack the succulent young tissues in the same fashion as is characteristic of the other two lilac strains of *Phytophthora.*

According to White's description (35) the infection caused by *Phytophthora cactorum* takes place in the succulent young shoots. "A die-back condition is caused by the invasion of the fungus in the cortex of the shoot, and in some cases suckers three and four feet

long have been killed to the ground. Frequently the entire crop of root suckers which arise about the base of old lilac bushes have been completely killed. On leaves, infections first appear as small, water-soaked areas, increasing in size during periods of rain, but drying out during periods of dry weather. Entire leaves may be invaded, and the fungus has been found growing down the petioles into the cortex of the branch where dark brown or black cankers are produced."

The disease observed in Boston follows in general the same course as that in New Jersey. Infections of the young shoots are observed soon after the buds have started development, and the disease is maintained through the summer months in the supply of soft young suckers which are constantly being formed at the bases of older lilac plants. Hardening of the wood completely checks the disease provided it has not advanced too far for the recovery of the shoot. The stem lesions appear to be more frequent, somewhat resembling those caused by *Bacterium Syringae* in being elongated, dark, and soft, but becoming hard and calloused in the cases where the shoots recover. Oospores are frequent in the diseased tissues, and sporangia are produced on the surfaces of the lesions during moist weather or if the lesions are placed in moist chambers.

The disease caused by *Phytophthora cactorum* var. *applanata* in all essential features resembles that caused by *P. cactorum*, so much so that no additional description is necessary, the lesions being confined to the succulent tissues, being dark, soft, and elongate, and becoming checked by the hardening of the tissues affected.

B. PREDISPOSING FACTORS

Phytophthora Syringae, as may be seen from the work on temperature relations of the fungi, is an organism favored by cool weather. It was noted above that its growth ceases at 25° C. (77° F.), and as this temperature is frequently exceeded in the spring and summer months it is not surprising to find that the disease caused by *P. Syringae* is essentially a disease of winter and early spring. Klebahn (18) found the disease to be primarily one of plants which had been closely packed in cool chambers for the winter and covered with leaves preparatory to forcing in the spring. Miss de Bruyn (6), in investigating more accurately the relation between season of the year and occurrence of the disease, found that a maximum number of successful stem inoculations could be made in November, the number decreasing to practically zero in the summer, and again increasing in the fall. The same was true of bud inoculations which reached a percentage of successful inoculations of 100% in Novem-

ber and December and fell to 0% in September. Moreover, she also reported that the increase in length of stem inoculations was greatest in February, falling to zero in July and again beginning a gradual increase in November.

On the contrary the other two Phytophthora strains causing lilac disease are fungi favored by higher temperatures. Accordingly it is consistent that the lesions caused by the latter are more prevalent during the spring and summer months and are absent during the winter.

Moisture plays an important role in the severity of all of the Phytophthora diseases of Lilac. Spread of the diseases in all cases is chiefly through the activity of the zoospores, the oospores being non-motile and buried within the tissues, to be freed only by the disintegration of the diseased parts. A high degree of humidity is essential to the production of sporangia, and water is necessary for the life and distribution of the zoospores. Therefore the rate of spread of the diseases is conditioned by the rainfall and humidity. Herein lies one reason for the destructiveness of the disease caused by *Phytophthora Syringae* in the European forcing beds. The plants which had been stored were covered with a moisture retaining layer of leaves which greatly facilitated the dispersal by zoospores. The increase in size of *P. cactorum* lesions in periods of rain has been noted above, and White has also observed that excessive shade and relatively high humidity are conducive to the spread of the disease caused by *P. cactorum*. Excessive rainfall also exerts a secondary influence upon the severity of the diseases caused by *P. cactorum* and its variety *applanata*. It is a matter of frequent observation that prolonged rainy seasons prolong the period before the new growth begins to harden. Accordingly, as the period of succulence is extended the opportunity for infection and enlargement of the lesions becomes proportionally increased. In the case of the disease caused by *P. Syringae*, rainfall has still another unfavorable influence. Miss de Bruyn has observed (6, 7) that during seasons with abnormal rainfall in August and September the development of the fungus concerned upon the leaves is greatly aided while leaf fall is retarded. The development of the fungus becomes sufficient, under such circumstances, that the fungus can pass down the petioles and into the cortex of the stems, thus establishing itself in the woody tissue and offering a source of infection for spread during the winter months.

As another predisposing factor should be mentioned the methods of planting and of cultivation. If Lilacs are so heeled in that the buds come to lie in proximity to the soil they are in a favorable

situation for infection, since *Phytophthora* species are able to exist saprophytically in the soil. Such a method of planting is frequently employed, and Klebahn called attention to the destructiveness of the infection by *P. Syringae* resulting. Lustner (24) observed that of two similar groups of Lilacs, one of which had been planted in normal fashion, the other heeled in, only the latter group suffered from the disease caused by *P. Syringae*. In the case of the diseases due to *P. cactorum* and *P. cactorum applanata* the method of cultivation may likewise exert an influence upon the severity of the disease. As it has been shown above that these diseases are maintained during the summer upon the succulent young suckers at the bases of old lilac plants, it is manifest that clean cultivation involving the continual removal of such suckers will decrease by much the amount of inoculum available the following spring. Such suckers improve neither the appearance nor the health of mature specimen Lilacs, and clean cultivation is hence doubly desirable.

A fourth predisposing factor may be injury. Klebahn was unsuccessful in causing infection with *P. Syringae* to woody stems unless these had been previously injured, and accordingly it is probable that infection in nature is facilitated by injuries. However, in the cases of the diseases caused by the other two lilac strains of *Phytophthora*, infection of the succulent growth appears to be independent of injury.

C. INFECTION EXPERIMENTS

In 1906 Klebahn succeeded in transmitting the disease caused by *P. Syringae* from Lilac to Lilac by means of pieces of infected cortex inserted into healthy lilac stems (17). In 1909 he reported a more extensive series of infection experiments using pure cultures of the fungus (18). He was able to secure satisfactory infections in wounds in the woody stems as well as in uninjured buds using mycelium as the inoculum, and likewise to infect successfully using pure cultures of swarm spores. He also carried out a series of infection experiments demonstrating that the fungus was not only able to infect Lilac but that it would likewise infect a variety of other related and unrelated hosts such as *Jasminum*, *Forsythia*, *Crataegus*, *Pyrus*, *Prunus*, *Acer*, *Aesculus*, *Alnus*, *Corylus*, *Quercus*, and *Tilia*. Negative results were obtained with a number of other inoculated subjects.

De Bruyn's inoculation experiments with the same fungus (6) have already been mentioned. It will be recalled that she was able to obtain a high percentage of infections on lilac during the winter, using mycelium as inoculum. The only other infection experiments with *Phytophthora* from Lilac are those of White in 1929 with *P.*

cactorum. White mentions (35) that he has successfully performed repeated cross inoculations with this organism between Lilac and Rhododendron, which latter is also parasitized by *P. cactorum* in nature.

During 1930 and 1931 a number of infection experiments were performed by the writer with all three strains of *Phytophthora* from Lilac. These will be summarized at this point.

On April 2, 1930 ten pot plants of *Syringa vulgaris* var. *purpurea* with stems of 1 cm. diameter were inoculated in knife wounds of the woody stems with mycelium from agar cultures of *Phytophthora Syringae*. The inoculations were bound with wet sphagnum and raffia in the conventional manner and placed in a large moist chamber. On examination five months later all the inoculations were negative. The failure was probably due to the time of year of inoculation since Miss de Bruyn likewise obtained almost negative results in inoculations performed in April.

The same experiment was repeated the following December using 24 similar host subjects and inoculating eight each with *P. Syringae*, *P. cactorum*, and *P. cactorum* var. *applanata*, respectively. The inoculations were performed as in the preceding experiment except that in some of the plants semi-woody tissues were inoculated, while in other plants only the woody stems were employed. The extent of spread of the lesions was observed three months later. The following table gives the results.

AVERAGE INCREASE IN SIZE OF LESIONS (mm.)

INOCULATION IN	P. SYRINGAE	P. CACTORUM	P. CACTORUM APPLANATA
Hard wood	23.0	17.2	17.6
Semi-woody tissues	1.2	4.0	3.0

The respective fungi were reisolated from the margins of the majority of the lesions three months after inoculation. The results indicate that although *P. Syringae* is most virulent in woody tissues, *P. cactorum* and *P. cactorum applanata* can also cause infection in such tissues. Since the inoculated plants were in a greenhouse the temperature of which was moderately high, *P. cactorum* and *P. cactorum applanata* were growing at a temperature favorable for their development and one which would not obtain at this season in nature.

A third infection experiment was performed in April, 1931, differing from the preceding in that the normal succulent growth was selected as the infection court. The inoculum was in the form of pure cultures of the three lilac strains of *Phytophthora* on agar. In some subjects a pair of leaves was removed from each succulent

shoot and the inoculum bound over the leaf scars, in others no injury was resorted to. The inoculations were then surrounded with moist cotton and raffia and placed in moist chambers. Five plants each were used for each strain of fungus. The results were as follows:

Host Inoculated	Organ Inoculated	P. Syringae		P. cactorum		P. cactorum applanata	
		Inocul's	Infect's	Inocul's	Infect's	Inocul's	Infect's
Syringa vulgaris	Succulent shoots	14	(2) (Very weak)	30	28	15	6
Syringa vulgaris	Blossoms					1	1
Ligustrum ovalifolium	Succulent shoots			12	2	8	(1) (Very weak)
Ligustrum ibota	Succulent shoots			2	0	2	0

In a number of instances in the infections with *P. cactorum* and *P. cactorum applanata* there was clear-cut evidence from the limits of the infections produced that the respective fungi had succeeded in penetrating through the uninjured epidermis. This experiment indicates that under more nearly natural conditions in the spring *P. cactorum* is highly virulent to succulent lilac tissues, *P. cactorum* var. *applanata* somewhat less so, and *P. Syringae* very weakly aggressive.

In the typical negative inoculations with *P. Syringae* indicated in the table there was frequently a small brown area marking the original entry of the fungus, but around this developed a layer of callus tissue, cutting off the lesion from the rest of the stem tissue. With the employment of *P. cactorum* and *P. cactorum* var. *applanata* the typical lesion took the form of a brown, soft area which appeared within 48 hours of the time of inoculation. Such brown areas were not necessarily restricted to injured points on the shoot. From the brown area watery streaks extended up and down the stem, looking as though the cells of the streaks had been mechanically crushed. Very rapidly these streaks turned brown and soft until the advance involved several centimeters after 96 hours. The shoots would then fall over at the rotted part and the distal portions would die. Cut leaf bases were readily occupied by both the fungi, but there was a partial checking of fungus growth at the layer of abscission, that is, the fungus appeared to pass that layer with some difficulty. The lesions were usually covered with *Phytophthora* mycelium when removed from the moist chamber.

The evidence from the preceding experiment shows that under some conditions *P. Syringae* is able weakly to infect succulent lilac tissues. In order to test this matter further, however, an experiment was set up in April 1931, using zoospores as inoculum. Glass

collars were fitted around the stems of 15 pot lilacs (*Syringa vulgaris purpurea*) each with a succulent shoot at the top of the stem and partly within the glass collar. The glass collars were fashioned and sealed in the manner described by Klebahn (18). Into the collars of ten of the plants were then poured pure cultures of freshly liberated zoospores of *P. Syringae*. The remaining 5 plants were similarly treated but using sterile water instead of the zoospore suspensions. The following day a second dose was given to 8 of the experimental plants and to four of the controls. The day after a third dose was given to 6 of the 8 mentioned above and to 3 of the controls. This process was repeated until the last two of the experimental plants had received 5 daily doses of the zoospore culture and the last control 5 doses of sterile water. The plants were later examined for infection. The results of the examination are given in the following table:

Number of days of treatment	Treated with	
	Pure culture of zoospores of P. Syringae	Sterile water (Control)
1	Slight infection	No injury
2	Typical infection	Slight browning
3	Typical infection	No injury
4	Typical infection	No injury
5	Typical infection	Slight browning

This experiment therefore, indicates that although *P. Syringae* is primarily a fungus causing disease in woody tissues of Lilac and in the winter, nevertheless, it is able under some conditions to cause an infection of succulent tissues in a manner similar to *P. cactorum* and *P. cactorum applanata*.

Summarizing the results of all the infection experiments performed to date with the lilac Phytophthoras, one can say that *P. Syringae* has been shown to be capable of causing infection in injured woody stems during the winter months but not during the summer months, in uninjured buds during the winter months, and in more succulent tissues under certain conditions in the spring and summer. However, it is primarily a parasite of dormant tissues. *P. cactorum* and *P. cactorum* var. *applanata*, on the contrary, have been proved to be more readily capable of causing disease in succulent tissues during the spring and summer than *P. Syringae*. On the other hand, although these latter fungi are also capable of parasitizing dormant tissues, they are less aggressive in such tissues than *P. Syringae*. The inoculation experiments thus confirm the observations that in nature *P. Syringae* is primarily the cause of a disease of dormant Lilacs, *P. cactorum* and its variety *applanata* primarily the causes of diseases of succulent young sprouts.

VI. PROGNOSIS AND CONTROL

The final chapter of such a study as the present one, and from the practical standpoint the most important one, necessarily must be concerned with the control of the diseases in question. However, before proceeding directly to the question of control it is advisable to consider briefly the conditions under which the diseases are likely to be most severe and to warrant active steps in control.

The Phytophthora diseases of Lilac under ordinary conditions are not as destructive as are many of the more devastating diseases of other economic plants. There is little likelihood of their increasing to epidemic proportions, at least under American conditions of lilac culture. On the other hand, given optima of moisture, temperature, and supply of inoculum, the diseases may well merit serious measures for control. This fact is particularly true of an ornamental plant such as the Lilac where infections of a severity which would not seriously diminish the quantity of product in crop plants, may in ornamental plants, nevertheless, diminish very appreciably the market or aesthetic value of the host.

The disease caused by *P. Syringae* in the European lilac forcing industry as well as in nurseries and private collections has already shown itself capable of warranting prophylactic measures. This has been particularly true in seasons in which there has been an abundance of rain in August and September and under cultural methods which facilitate the development of the lesions and the spread of inoculum. Such methods are those by which Lilacs are closely packed in relatively air-tight chambers, preparatory to shipment, transplantation, grafting, or forcing. On the other hand, where Lilacs are well spaced, growing under more or less natural conditions outdoors in the private collection or nursery, the spread of the disease is much less readily accomplished, and control by natural agencies will probably be relatively effective.

As regards the other diseases caused by *Phytophthora cactorum* and *P. cactorum* var. *applanata*, the conditions favoring the diseases are somwehat different. Here the diseases are more likely to become epidemic in natural plantings, particularly during those seasons in which the spring rains are prolonged. Moreover, as spring is the season of the year during which the Lilac attracts most attention, infections in the foliage and blossoms in the spring are doubly important. Hence it will be seen that the latter diseases may at times be rather important under American conditions of lilac culture. It certainly will be to the advantage of the lilac grower to examine his plants during early spring and up to blossoming time for Phytophthora infections, especially during the more rainy seasons, and to

take prompt steps to check any serious impending spread of infection.

The methods of prophylaxis against a Phytophthora disease in Lilac depend upon the species of *Phytophthora* involved. Control of the European disease, caused by *P. Syringae*, has been worked at rather at length by both Klebahn and de Bruyn. Klebahn's suggestions (18) include the removal and burning of all infected plant parts, cultural methods which eliminate the close heeling-in of stored Lilacs, maintainance of a low degree of humidity in stored lilacs especially by elimination of leaves as a covering for such plants, and finally avoidance of mechanical injuries to the Lilacs by careful cultural practices. After a few years of observance of such suggestions, Klebahn felt that the disease had been somewhat diminished in frequency. He suggested that fungicides, used during storing and eventually in the nursery, might be of value, but he did not test their efficacy. Miss de Bruyn (6) originally added to Klebahn's suggestions the desirability of removing the infected leaves by hand during such years as show an abnormal rainfall in August and September, but a later study (8) showed that the quality of the blooms was so decreased by such treatment that the method was not considered advisable. She also suggested Bordeaux and lime-sulphur sprays, cautioning at the same time against spray injury to the young tissues.

As regards the other Phytophthora diseases of Lilac, the experimental conditions have not been favorable to a thorough comparison of control measures. However, a knowledge of the success of prophylactic treatments in diseases caused by similar fungi and of the physiology of the fungi involved here leads one to a number of *a priori* suggestions. White's recommendations for the control of the disease caused by *P. cactorum* (35) embody avoidance of planting of Lilacs near to Rhododendrons (since the fungus involved also parasitizes Rhododendron), removal and burning of dead wood, soil sterilization where practicable, discreet pruning, and spraying with a dormant application of lime-sulphur together with summer applications of Bordeaux.

In the control of both of the latter diseases good cultural methods should prove most useful. The ideal Lilac, according to most growers, is a single-stemmed plant of the general form of an inverted cone. An abundant crop of suckers at the base detracts both from the aesthetic value of a plant and from its ability to blossom. Moreover, it is the suckers which materially aid in carrying the infection through the summer. Hence the complete and regular removal of such suckers is to be advocated. Combined with this, care should

be taken to keep the bushes properly spaced and thinned out in order to avoid excess of moisture and shade. During the spring, particularly during wet seasons, frequent examinations should be made for Phytophthora lesions on the young growth, and if such lesions are found they should be immediately destroyed. If lesions occur to a considerable extent on the shrubs, protective applications of Bordeaux are indicated, and without delay, since the spread of the diseases is very rapid under such conditions. It has been suggested that the spotting caused by the Bordeaux may be deleterious to the appearance of the plants. Such an objection would not apply to the nursery, but in private collections the spotting might be avoided by the substitution of one of the non-spotting fungicides now on the market. Methods of soil sterilization for the most part could not be conveniently applied to standing lilacs, but under the conditions of some propagation practices it would be well to consider soil sterilization in case of a severe attack by *Phytophthora cactorum* or *P. cactorum applanata* on nursery stock.

The efficacy of Bordeaux spray and sulphur dust as protective agents were investigated in the following manner. Water cultures of the three Phytophthora strains were prepared in order to obtain suspensions of freshly liberated zoospores. Drops of the zoospore suspensions of each fungus were then placed on microscope slides which had been in one case dusted with a reputable commercial sulphur dust, in a second case sprayed with a 4-5-50 Bordeaux mixture, and in the third case untreated. Examinations were first made for loss of motility of the zoospores. It was found that with *P. Syringae* the untreated spores remained active for about an hour, the Bordeaux treated spores lost all motion within 5–10 minutes, and the sulphur treated spores lost all motion in about 20 minutes. With the spores of *P. cactorum* the controls remained active for nearly an hour, and those treated with Bordeaux and sulphur for 10–20 minutes. With *P. cactorum applanata* the controls remained active for nearly an hour but all motion was lost in the spores treated with both Bordeaux and sulphur in less than 5 minutes.

As regards germination, the control spores of *P. Syringae* germinated to an extent of about 90% in 24 hours, those of *P. cactorum* to about 99%, and those of *P. cactorum applanata* to about 80%. Meanwhile the Bordeaux treated spores of all three strains completely failed to germinate, while the sulphur treated spores germinated in *P. Syringae* 85%, in *P. cactorum* 77%, and in *P. cactorum applanata* 70%.

This experiment accordingly indicates that Bordeaux of a strength of 4-5-50 will completely inhibit zoospore germination in all the

lilac strains of *Phytophthora*. Hence in the field one would anticipate that Bordeaux would offer a very satisfactory protection, since infection in the field is apparently almost or quite exclusively by zoospores. On the other hand, sulphur dusting would not be expected to give satisfactory results since it exerts very little inhibiting effect upon zoospore germination.

VII. SUMMARY

1. The present paper reports a comparative study of three strains of *Phytophthora* parasitizing Lilac, and of the diseases caused by them. The fungi involved are *Phytophthora Syringae* (Kleb.) Kleb., *P. cactorum* (L. & C.) Schroet., and a third strain here tentatively referred to as *Type A*.

2. The physiological behavior of the three strains of *Phytophthora* was investigated with the following results:

a. In regard to rate and type of growth upon a variety of artificial substrata, *Phytophthora Syringae* was found to differ markedly in its reactions from the other two strains, while the latter, although in general similar to each other, showed certain suggestive differences.

b. With respect to production of reproductive organs upon a variety of artificial media, *P. Syringae* again proved to be entirely distinct, while certain minor differences distinguished *P. cactorum* and *Type A*.

c. In relation to temperature, *P. cactorum* and *Type A* were found to vegetate luxuriantly at temperatures as high as 25° C, at which temperature *P. Syringae* failed to make any growth. The optimum temperature for the former two strains was found to be in the neighborhood of 25° C., in contrast to 20° C. for *P. Syringae*.

d. The strains manifested corresponding differences with regard to pH. *P. Syringae* vegetated well between pH 3.5 and 7.0, growth virtually ceasing at 7.5, *P. cactorum* showed good growth in the very long range from 3.0 to 10.0, while *Type A* grew satisfactorily between 3.0 and 9.5. In passing, the subject of vital staining of the lilac strains of *Phytophthora* was investigated. Staining of the vacuoles was observed with neutral red but not with methyl red, indicating that the vacuoles of these strains of *Phytophthora* are of the type designated by Bailey as Type B. Methyl red was not reduced by *P. Syringae* but was reduced by the other two strains. The oospore walls of *P. cactorum* and *Type A* were brilliantly stained *in vivo* by a number of the stains employed.

3. The morphology of the three strains of *Phytophthora* was likewise investigated with the following results.

a. Minor, but no important differences were observed in the mycelial characters of the three strains.

b. The sporangia differed markedly with respect to the type of papilla of zoospore emergence. That of *P. cactorum* was strikingly different from those of *P. Syringae* and *Type A* in being very prominent, in contrast to the flattened, inconspicuous papillae of the other strains. This character was striking and constant, and was the most useful criterion for distinguishing the otherwise similar *P. cactorum* and *Type A*.

c. Few significant differences were observed in the sexual apparatus of the three strains. The antheridia were mainly paragynous and the mycelia homothallic in all the strains. There was, however, a significant difference in oospore size between *P. Syringae* and the other two strains.

d. Abortive reproductive structures are discussed as they occur in the three strains.

4. On the basis of the work on the comparative physiology and morphology of the three strains, their respective systematic positions are discussed. *Type A* was found to resemble *P. cactorum* more closely than any other species of the genus. However its different form of papilla, together with other more minor differences, have lead to its recognition as a new variety of *P. cactorum*, namely *P. cactorum* var. *applanata*, n. var., the diagnosis of which is given.

5. The comparative pathology of the three lilac strains of *Phytophthora* was investigated. *P. Syringae* was found to differ markedly from the other strains in the type of lesion produced, the tissues attacked, and the time of year of greatest fungus activity. *P. cactorum* and *P. cactorum* var. *applanata* behaved in a similar fashion pathologically. The symptoms caused in Lilac by the three strains of *Phytophthora* are described, the factors predisposing to the diseases caused are analyzed, and the pathogenicity of the three strains under various conditions determined by infection experiments.

6. On the basis of the comparative study of the fungi and of the diseases caused by them, the probable severity of the diseases is discussed, together with the conditions under which the diseases are likely to prove most destructive. Finally the possible methods for the control of the diseases are considered and recommendations made as to the prophylactic practices found desirable.

VIII. ACKNOWLEDGEMENT

The study herein reported has been materially aided by the suggestions of Professor J. H. Faull to whom I wish to express my

thanks. Acknowledgement is also due to Professor I. W. Bailey for suggestions regarding the experiments in staining *in vivo*.

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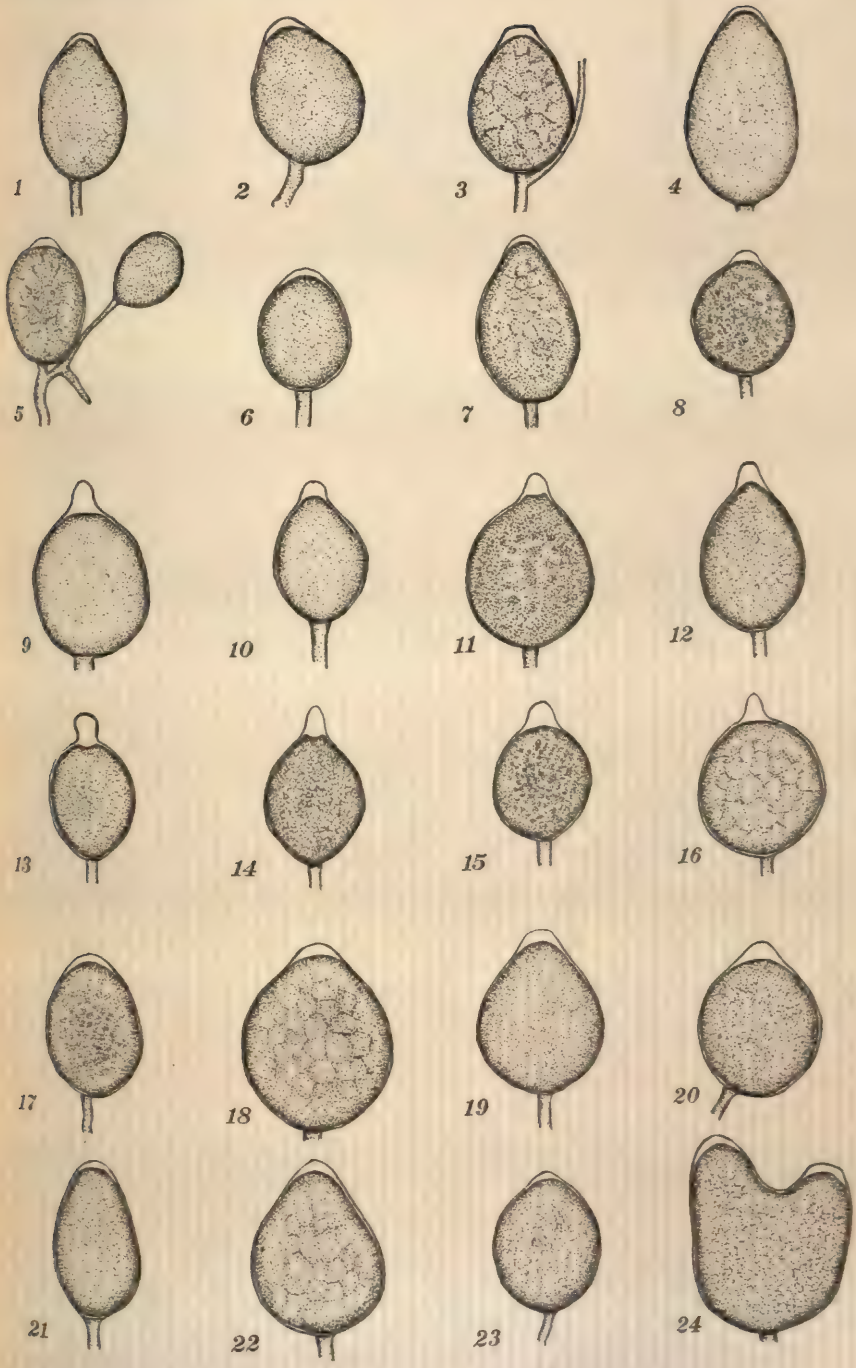

Phytophthora Diseases of Lilac

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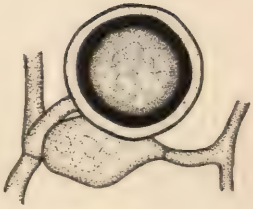

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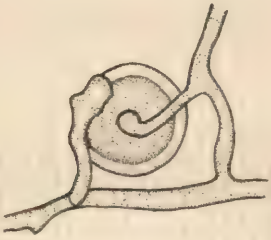

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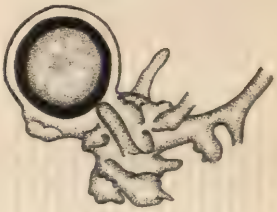

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Phytophthora Diseases of Lilac

EXPLANATION OF PLATES 46 AND 47

Figs. 1–24. Sporangia of the lilac strains of *Phytophthora*. Camera lucida drawings from living material. × 1000.

Fig. 1–8. *Phytophthora Syringae*. Typical sporangia illustrating the general structure and flattened type of papilla

Fig. 9–16. *P. cactorum*. Typical sporangia illustrating the prominent type of papilla characterizing this species.

Fig. 17–24. *P. cactorum* var. *applanata*. Typical sporangia except for Fig. 24 which represents a bicornute abortive type frequent in old water cultures. Illustrative of the flattened papilla which differentiates this variety from *P. cactorum*. Fig. 20 represents as well developed a papilla as has been seen in this variety, the majority of the sporangia in cultures of *P. cactorum applanata* being of the form indicated in Figs. 17, 18, 21, and 22.

Figs. 25–34. Sexual reproductive organs of the lilac strains of *Phytophthora*. Camera lucida drawings from living material. × 500.

Fig. 25, 26. *P. Syringae*. Fig. 25, oogonium; Fig. 26, oospore. Showing the typical basally paragynous antheridia.

Fig. 27–30. *P. cactorum* var. *applanata*. Figs. 27, 29, oogonia; Figs. 28, 30, oospores. Illustrating in Fig. 29 the homothallic nature of the vegetative body and in Fig. 30 the highly proliferate type of antheridium frequently found in old cultures.

Fig. 31–34. *P. cactorum*. Oospores. Figs. 32 and 34 demonstrate the heterothallic nature of the mycelium, while the typical basally paragynous antheridia are best evident in Figs. 31 and 33.

PARASITISM OF MYXOMYCETE PLASMODIA ON THE SPOROPHORES OF HYMENOMYCETES

FRANK L. HOWARD AND MARY E. CURRIE

With plates 48 and 49 and two text figures

THE interest of authors was aroused in the subject of the parasitism of Myxomycetes when they found plasmodia creeping over and destroying the fruitbodies of mushrooms and polypores in the forests. Because Myxomycetes are usually found on decaying wood, dead leaves, and other organic debris, the notion is current that their nourishment is derived chiefly from the bacterial and fungous decomposition of these substrata. Even though myxomycetous sporangia are occasionally found on disintegrating fructifications of polypores, mushrooms, and other fungi in the forests, collectors rarely conceive of the disintegration observed as being due to the plasmodia from which the sporangia are formed. There are students of the Myxomycetes, however, who have been impressed by the possibility of their active parasitism on fungi, as is pointed out in our résumé of the literature. The authors of the present paper have independently made extensive observations on the mycophagy of the slime molds in the field and supplemented them with tests in the laboratory. The results, dealing with the nutritional relationships of a considerable number of the Myxomycetes to the sporophores of fungi, and the process by which the plasmodia digest the fungal tissues, are presented here.

The general method used to obtain plasmodia for this study was, either to collect them upon Hymenomycetes or other substrata and to bring them into the laboratory, or to grow them from spores in culture upon suitable nutrient agar media. During the season when mushrooms were available, as many different kinds as possible were gathered, identified, and placed in large petri or crystallizing dishes lined with moist filter paper or paper toweling. The sporophores were inoculated by placing a piece of plasmodium varying from 0.5 to 2.5 sq. cm. in area upon the apex of the stipe of stipitate fruitbodies or at the base of sessile forms. Notes were taken daily upon the virulence of the attack and the nature and extent of the tissues of the host being digested. Details of the process of destruction of the fungous tissues were obtained, either from microscopic examination of living material, or from examination of material fixed in Navaschin's, Bouin's, or chrom-acetic solution.

cut into sections 3 μ to 10 μ thick after embedding in paraffin, and stained with Flemming's triple or with iron-alum-haematoxylin.

The observations reported in this paper are the result of two independent investigations upon this subject. The junior author, now Mrs. Gordon Edwards, carried on her work as a graduate student in the Botanical Laboratories of the University of Toronto, during the years 1919–1921, under the direction of Professor J. H. Faull, now Professor of Forest Pathology at the Arnold Arboretum, Harvard University. The observations contributed by the senior author were made at Harvard University under the sponsorship of Professor W. H. Weston, Jr., during the tenure of a National Research Fellowship in the Biological Sciences, 1930-1931.

REVIEW OF THE LITERATURE

The literature contains several references to plasmodia attacking Hymenomycetes which indicate that mycophagy is not uncommon among the Myxomycetes. For the first reference to their parasitism we must look to A. Lister (8), who in January 1877 was led to investigate the parasitism of fungi by the Myxogastrales upon finding *Corticium puteanum* fruitbodies being consumed by a plasmodium of *Badhamia utricularis*. He kept this plasmodium in culture by feeding it sporophores of several species of Basidiomycetes, and although he found that the plasmodium could make use of the majority of these, it showed preferences. In some cases almost the entire fruitbodies were assimilated but in others merely the soft superficial tissues were used. The Myxomycete flourished on *Corticium puteanum*, *Polyporus versicolor*, *P. adustus*, *Merulius* sp., and *Daedalea* sp.; was most luxuriant on *Stereum hirsutum;* rapidly consumed *Boletus flavus* and *Agaricus* (*Psalliota*) *campestris;* slowly attacked *Agaricus* (*Armillaria*) *melleus;* and with great difficulty attacked *Agaricus* (*Amanita*) *rubescens* and *Agaricus* (*Hypholoma*) *fascicularis*. Lister observed that the decomposition products of the attacked fungi many times had a deleterious effect on the plasmodium. He noticed also that there was usually a heavy mucus-like residue which varied in amount with the species of Basidiomycete and in which Mucors and other fungi were apt to grow. He made a microscopic examination of the plasmodium attacking hyphae of *Stereum hirsutum* and found that the threads dissolved and broke in pieces as the hyaloplasm advanced over them.

Blytt (1) in 1879 collected the type of *Clastoderma Debaryanum* on a dead *Polyporus* sp., and Brunaud (2) in 1890 reported finding sporangia of *Enerthenema papillatum* on the debris of a *Corticium*,

Fuligo septica on the pileus and hymenium of a Polypore, and *Stemonitis fusca* on the debris of *Polyporus versicolor*, but neither observer suggests that these Myxomycetes may be parasitic upon the fungi concerned. Likewise, Jahn (7) reports Möller as finding *Trichamphora pezizoides* fruiting on a pileus of *Lentinus villosus*.

Macbride (9) reported the second recognized case of a mycophagous myxomycete when he found that the plasmodium of *Physarum polycephalum* would rapidly digest sporophores of *Agaricus* (*Pleurotus*) *sapidus*.

Harshberger (6) shortly afterwards discovered a bright yellow plasmodium attacking *Pleurotus sapidus* sporophores in the field. Upon bringing the plasmodium, which he named *Fuligo septica*, into the laboratory he found that it would attack and digest pieces of *Coprinus comatus*, *C. atramentarius*, *Hypholoma perplexum* and the gleba but not the stipe of *Phallus impudicus*.

Atkinson in 1916 presented a paper before the Mycological section of the Botanical Society of America upon a slime mold parasitic on mushrooms, which was believed to be a *Badhamia*, but this paper has never been published.

Elliott (4) collected further data regarding the action of *Badhamia utricularis* on fungous tissues. He noted the same discrimination for various species of mushrooms as that described by Lister (8). Elliott experimented with *B. utricularis* on *Polystictus versicolor*, *P. hirsutus*, *Polyporus dryadeus*, *Amanitopsis vaginata*, *Amanita rubescens*, *Collybia dryophila*, *Coprinus micaceus*, *Laccaria* (*Clitocybe*) *laccata*, *Marasmius oreades*, *Panus stipticus*, *Psilocybe semilanceata*, *Russula furcata*, *R. rubra*, *R. emetica*, *Stropharia semiglobata*, *Boletus scaber*, *B. flavus*, and *Lycoperdon gemmatum*. Elliott observed that unless the plasmodium is able to move away from its host after the decomposition of the fungus sets in, it is killed. In conclusion, he writes that the plasmodium of *Badhamia utricularis* can assimilate nearly all of the fleshy fungi whether poisonous or otherwise. In a later paper with Jessie S. Elliott (5) he describes the sequence of fungi and Myxomycetes upon a large oak branch subsequent to its fall in 1912. Fruitbodies of *Bulgaria polymorpha*, *Coryne sarcoides*, *Stereum hirsutum*, *Panus stipticus*, and *Hypholoma fasciculare* (*H. fasciculare*) appeared in order upon the branch, but only those of *H. fasciculare* and *S. hirsutum* were in evidence in 1919 when the first Myxomycete, *Physarum nutans* Pers., made its appearance. Sporophores of *Phlebia merismoides*, *Hypholoma sublateritium* and one of *Pluteus cervinus* were new additions before other crops of *Physarum nutans* appeared in June 1920. In July 1920 the white plasmodium of *Stemonitis*

fusca emerged from the branch but nothing is said regarding its parasitism. The complete disappearance of *Bulgaria polymorpha* and *Coryne sarcoides* is attributed to the destruction and absorption of their mycelia within the wood by *Physarum nutans*.

Currie (3) in 1919, besides reporting *Badhamia utricularis* and *Physarum polycephalum* to be mycophagous, added three more species to our list of Myxomycetes which parasitise fungi, namely: *Badhamia foliicola* List., *B. magna* Peck, and *Physarum flavicomum* Berk.

Sanderson (11, 12) further supplemented the list by reporting two Myxomycetes which attacked fungous sporophores in Malaya. He observed the plasmodium of *Physarum viride* var. *rigidum* (*P. rigidum* G. Lister) attacking the fructifications of *Schizophyllum commune* and *Hirneola hispida* but not the fructifications of *Daldinia concentrica*, *Ustulina zonata*, and *Nummularia pithodes*. Likewise, he observed the dirty gray plasmodium of *Trichamphora pezizoides* covering and feeding upon the fruitbodies of *Schizophyllum commune*, "*Tremellina* sp.", *Daldinia* sp., and *Ustulina zonata*.

An examination of the foregoing résumé of the literature shows that of the seven mycophagous species of Myxomycetes reported, all belong to the family *Physaraceae* and that yellow-colored plasmodia predominate. Species classified in other families have been observed by the authors to be parasitic upon fungous tissues, to an account of which we now turn.

MYXOMYCETES FOUND TO BE PARASITIC AND THEIR FUNGOUS HOSTS

During these investigations, thirty-three different plasmodia were tested for their parasitism upon fruitbodies of Hymenomycetes. Fifteen species, representing four families of the Myxomycetes, were identified as follows: *Badhamia foliicola* List., *B. magna* Pk., *B. rubiginosa* Rost., B. *utricularis* Berk., *Fuligo septica* Gmel., *Physarum flavicomum* Berk., *P. polycephalum* Schw., *P. tenerum* Rex., *P. virescens* Ditm., *Leocarpus fragilis* Rost., *Brefeldia maxima* Rost., *Lindbladia effusa* Rost., *Lycogala epidendrum* Fr., *Hemitrichia clavata* Rost., and *Trichia decipiens* Macbr. Of the eighteen remaining plasmodia used, one was found to belong to the genus *Lamproderma* and another to the genus *Physarum*, but the others either failed to form sporangia or the sporangia were so aberrant that they could not be identified. These unidentified plasmodia were white, gray, yellow, and red in color, and were proved to be but weakly parasitic with one exception, plasmodium BFU, whose host range will be given later. Notes on the parasitism of the

various identified species, as exhibited in the forest and by laboratory tests, are presented in the following paragraphs.

Badhamia foliicola List. was found creeping over and feeding upon many fruit-bodies of *Polyporus resinosus* by A. W. McCallum in the late autumn of 1918. The bright yellow plasmodium was eroding and channeling the pore surface noticeably.

Badhamia magna Pk. seems to be selectively parasitic, since the plasmodium grew rapidly at the expense of the tissues of *Collybia succosa* and *Trametes pini*, slightly increased in size but did little damage to *Fomes applanatus*, and died upon sporophores of *Collybia hygrophoroides*, *Coprinus micaceus*, and *Mycena galericulata*.

Badhamia rubiginosa Rost. increased slightly in size upon *Collybia hygrophoroides*, *C. succosa*, and *Polyporus versicolor*, but failed to attack *Amanita flavoconia*, *Coprinus micaceus*, *Cortinarius lilacinus*, *Hypholoma sublateritium*, *Mycena galericulata*, *Pleurotus ostreatus*, *P. sapidus*, *Polyporus betulinus*, and *P. sulphureus*.

Badhamia utricularis Berk. apparently may frequently attack *Polyporus resinosus* in the forest, since four collections of eroded sporophores of this fungus bearing *Badhamia utricularis* sporangia are represented in the University of Toronto herbarium. One very large sporophore of *Polyporus resinosus*, consisting of several subimbricate laterally connate brackets, the largest 16 cm. wide and the smallest 8 cm. wide was collected by Professor Faull. Practically the whole of the pore surface was demolished and the upper surface was furrowed where all of the fluffy superficial tissues had been consumed.

Physarum flavicomum Berk. was found attacking a fresh fruit-body of *Lentinus lepideus* in the field in October 1919 by J. H. Faull. The greenish-yellow plasmodium had reduced the gills to a slimy bacteria-infested mass. Later the same species was found on one occasion attacking the pore surface of *Polyporus lacteus* and on another, rapidly destroying a large group of *Merulius tremellosus* sporophores. These plasmodia were brought into the laboratory, kept in culture upon agar media, and used to inoculate other species of mushrooms. Although the plasmodium is a gross feeder it does not attack all of the fungi with equal intensity, so, for convenience, the fungi are grouped according to the character of the attack by the Myxomycete. Included in the group of Hymenomycetes upon which the plasmodium flourished especially, so that it rapidly increased in size and more or less eroded the whole fruitbody before moving away, are: *Flammula polychroa*, *Lentinus*

lepideus, *Merulius tremellosus*, *Pleurotus ostreatus*, *P. serotinus* (Plate 49, fig. 9), and *Polyporus resinosus*. In the group upon which the plasmodium became so sluggish that it rarely moved away before both the sporophore and itself were attacked by secondary invaders are: *Collybia velutipes*, *Hypholoma sublateritium*, *Mycena* sp., *Pholiota marginata*, *Psalliota campestris*, *Polyporus adustus*, and *P. pargamenus*. A third group, *Armillaria mellea*, *Claudopus nidulans*, *Clitocybe multiceps*, and *Pleurotus ulmarius* were only slightly attacked by the plasmodium which usually died before it caused much damage. The last group includes those sporophores which the plasmodium failed to attack, namely: *Gyrocephalum* sp., *Lycoperdon* sp., *Tremella* sp., and *Tricholoma personatum*.

Physarum polycephalum Schw. plasmodia are quite frequently found destroying mushrooms and Polypores in the woods. Sporangia were collected in the summer of 1917 by J. H. Faull at Alexandria, Pa., and at Ithaca, New York, where before forming spores the plasmodia had been feeding on *Pleurotus ostreatus*. In July 1921 a large maple log was discovered bearing hundreds of *Pleurotus ostreatus* sporophores most of which were reduced to slimy pendant masses by the yellow plasmodium of *Physarum polycephalum*. Intermixed with the *Pleurotus* fruitbodies were fresh sporophores of *Fomes applanatus* and nearby was a cluster of *Mycena Leaiana* which were untouched by the plasmodium. Ten days later, on another maple log fifty yards from the one upon which the former collection was made, a large number of sporophores of *Pleurotus petaloides* was found scarcely one of which was not attacked by *Physarum polycephalum*. Again in early September of the same year a dead Elm tree was discovered with clusters of *Pleurotus ostreatus* intermixed with *Fomes applanatus* at its base, and while the former were being consumed by the plasmodium of *Physarum polycephalum*, the latter were untouched. One of the sporophores of *Fomes applanatus* was brought into the laboratory and there inoculated with a plasmodium which rapidly attacked the hymenium, as shown in plate 49, fig. 10.

The results of inoculations of fungous fruitbodies show that with *Physarum polycephalum*, as is also true for the other species investigated, the plasmodium does not attack all fungi with equal intensity. Some plasmodia may attack only the hymenial surface or the trama of a pileus while others may destroy the entire sporophore, none will wholly consume any fruitbody—there is always an undigested residue even though it be but the merest outline.

The fungi inoculated with the plasmodium of *Physarum poly-*

cephalum are grouped according to the ability of the Myxomycete to parasitise them. Those on which the plasmodium increased rapidly in size by digesting a large part of the sporophore are: *Amanita flavoconia*, *A. muscaria*, *A. phalloides*, *A. verna*, *Amanitopsis vaginata*, *Armillaria mellea*, *Cantharellus cibarius*, *Claudopus* sp., *Clitocybe dealbata*, *C. illudens*, *C. multiceps*, *Clitopilus prunulus*, *Collybia dryophila*, *C. radicata*, *Coprinus atramentarius*, *C. micaceus*, *Cortinarius lilacinus*, *Hygrophorus Peckianus*, *Hypholoma sub*

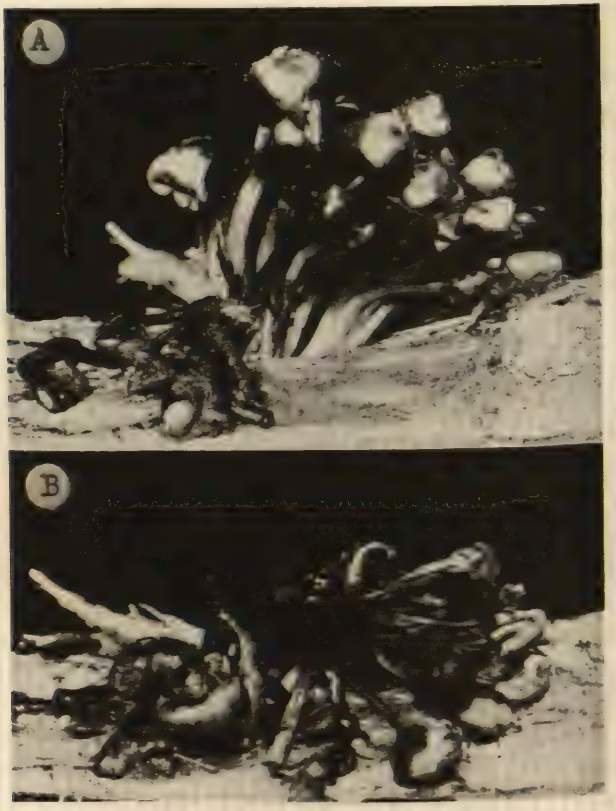

Fig. 1. *A*. Sporophores of *Mycena alcalina* inoculated twelve hours previously with the plasmodium of *Physarum polycephalum*. Several fruitbodies on the left have been enveloped by the plasmodium and have collapsed on the substratum. *B*. Twenty-four hours later practically every sporophore has been attacked and many have been left as soft black masses of tissue.

lateritium, *Lactarius volemus*, *Lepiota brunnea*, *L. naucina*, *Mycena haematopa*, *Pleurotus petaloides*, *P. serotinus*, *P. ostreatus*, *Pluteus cervinus*, *Russula roseipes*, *Tricholoma album*, *Boletus scaber*, *B. speciosus*, *Merulius tremellosus*, and *Polyporus betulinus*. It seems

strange that *Polyporus betulinus*, although much firmer in texture than other members of the above group, is hardly surpassed as a host for *Physarum polycephalum*.

The fungi which were attacked more slowly, but on which the plasmodium fed for a comparatively long time, are: *Fomes applanatus* (Plate 49, fig. 10), *Lenzites betulina*, *Polyporus adustus*, *P. fron-*

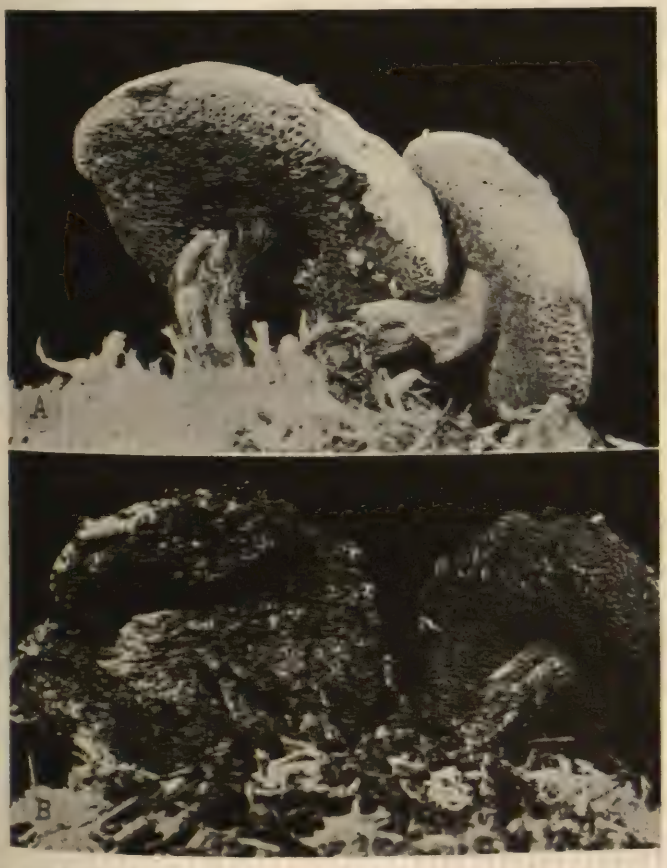

Fig. 2. *A*. Sporophores of *Boletus subtomentosus* twelve hours after inoculation with *Physarum polycephalum*, showing the plasmodium eroding the stipe and destroying the adjacent pores of the fruitbody on the left, and moving over the stipe of the one on the right. *B*. Twenty-four hours later the pileus at the left is a soft disintegrating black mass. The pores of the pileus on the right are about to be attacked.

dosus, *P. hirsutus*, *P. pargamenus*, *P. resinosus*, *P. Schweinitzii* (Plate 48, figs. 3–4), and *P. versicolor*. The sporophores which *Physarum polycephalum* attacked virulently, but oftentimes from which the plasmodium moved so sluggishly that when putrefaction

began it disintegrated with the host, are: *Collybia succosa* (Plate 48, figs. 1–2), *Flammula polychroa*, *Hypholoma appendiculatum*, *H. velutinum*, *Mycena alcalina* (Text-fig. 1), *Pholiota praecox*, *Pleurotus sapidus*, *Psalliota campestris*, *P. placomyces*, *P. Rodmani*, *Russula fragilis*, *Boletus felleus*, *B. subtomentosus* (Text-fig. 2), *Strobilomyces strobilaceus*, *Polyporus sulphureus*, *Hymenochaete badio-ferruginea*, *Hydnum repandum*, *H. septentrionale*, *Hydnellum scrobiculatum*, *Clavaria aurea*, *C. fusiformis*, *C. Kunzei*, and *Tremella lutescens*. The plasmodium of *Physarum polycephalum* failed to attack *Claudopus* sp., *Clitocybe pithyophila*, *Pleurotus ulmarius*, *Tricholoma personatum*, *Poria corticola*, and *Lycoperdon* sp.

Positive statements regarding the intensity of the plasmodial attack upon a certain fungus host are difficult to make, since the maturity and condition of each sporophore tested may make a difference. In some trials *Hydnum septentrionale* was not attacked after inoculation with the plasmodium of *Physarum polycephalum*, while in other trials the plasmodium consumed almost the entire sporophore. The same was true of *Amanita phalloides* and of *Russula emetica*. A good example of the effect of the maturity of the sporophore upon the parasitism of the Myxomycete was shown by *Physarum polycephalum* upon *Coprinus micaceus*. If the plasmodium was placed upon the gills of a young pileus, the plasmodium grew rapidly at the expense of the gills and trama, but if the gills had changed in color from white to reddish purple or had begun to deliquesce, the plasmodium was killed.

Physarum tenerum Rex. rapidly attacked *Merulius tremellosus*, but very slowly attacked *Coprinus atramentarius*, *Lepiota brunnea*, *Polyporus adustus* and *P. pargamenus*.

Physarum virescens Ditm. was unable to attack *Coprinus micaceus*, but made a slight growth upon *Collybia succosa*.

Fuligo septica Gmel. failed to attack the sporophores of *Clitocybe multiceps* and *Clitopilus prunulus* when the typical yellow plasmodium was used as inoculum. When two white plasmodia, whose aethalia formed in cultures have been identified as *Fuligo septica*, were tested on fungi, they destroyed the tissues of some fruitbodies. The sporophores of *Amanita muscaria*, *Pleurotus petaloides*, *Tricholoma album*, *Boletus scaber* and *Merulius tremellosus* were rather rapidly attacked, while those of *Amanita phalloides*, *A. verna*, *Lactarius volemus*, *Lepiota naucina*, *Pleurotus ostreatus*, *Boletus speciosus*, *Polyporus Schweinitzii*, and *Tremella lutescens* were attacked more slowly. The fruitbodies of the following fungi were not attacked: *Hygrophorus Peckianus*, *Russula emetica*,

Polyporus betulinus, *P. sulphureus*, *Poria corticola*, and *Hydnum septentrionale*.

Leocarpus fragilis Rost. increased slightly in size upon sporophores of *Collybia succosa*, but fruitbodies of *Coprinus micaceus*, *Mycena galericulata*, *Fomes applanatus*, and *Trametes pini* inoculated with the plasmodium were unattacked.

Brefeldia maxima Rost. made a slight growth upon *Collybia hygrophoroides* and *Fomes applanatus*, but none on the pilei of *Coprinus micaceus*.

Lindbladia effusa Rost. failed to grow on *Mycena galericulata* and *Coprinus micaceus*.

Lycogala epidendrum Fr. made a slight growth upon the apothecium of a *Peziza* and upon the mushroom *Mycena galericulata*, but it failed to attack *Mycena Leaiana* and *Coprinus micaceus*.

Hemitrichia clavata Rost.; the plasmodium attacked sporophores of *Mycena galericulata* and made a fair growth upon them, but it failed to attack *Collybia hygrophoroides*, *C. succosa*, *Coprinus micaceus*, and *Mycena Leaiana*.

Trichia decipiens Macbr. grew quite rapidly at the expense of the tissues of *Mycena Leaiana*, grew slightly upon *Mycena galericulata* and *Collybia hygrophoroides*, but did not attack *Coprinus micaceus*.

Lamproderma sp. seemed to attack *Hypholoma sublateritium* slowly but proved innocuous on *Pleurotus ostreatus*, *P. petaloides*, *P. sapidus*, *P. ulmarius*, and *Poria corticola*.

An unidentified yellow plasmodium (BFU) proved to be extremely parasitic and rapidly destroyed *Coprinus atramentarius*, *Hypholoma sublateritium*, *Lepiota brunnea*, *Pleurotus ostreatus*, *Russula emetica*, *Boletus scaber*, *Merulius tremellosus*, *Polyporus betulinus*, *P. adustus*, *Poria corticola*, *Daedalea confragosa*, and *Hymenochaete badio-ferruginea*.

The number of Myxomycetes whose plasmodia utilize fungi for food is far from being known and must await the cumulative observations of more workers in the future. Likewise, the complete range of fungi one species of plasmodium may parasitise is not known, but we may safely conclude from the long list of fungi that *Badhamia utricularis* and *Physarum polycephalum* are known to attack, that some species are very general parasites. Other species, as yet, appear to be non-parasitic upon fungi.

The tougher, more resistant tissues of the woody Polypores

account for the slower attack by plasmodia upon them. The plasmodia move over the surface of the pores digesting the basidial layer and sometimes completely destroying the pores, as seen in Plate 48, figs. 3–4. As a contributing factor of great importance in the destruction of the sporophores, it should be noted that all the observed plasmodia remove the surface layers and leave the Polypore with a moist slimy coating; a very favorable substratum for the development of Mucors, bacteria, and other secondary invaders.

This parasitism of Myxomycetes on fructifications of fungi is not confined to the laboratory, for during one season (1931) twenty-two plasmodia were found in the forest apparently feeding on the fungi with which they were associated. Birch and maple logs, decayed by various Polypores and Agarics, proved to be a favored haunt of the majority of these plasmodia, but three were found destroying fungi on an oak stump, one on a dead standing Chestnut (*Castanea dentata*), and another on a dead standing Pine. Although field observation of the parasitic habit of plasmodia first aroused our interest in this problem, study in the laboratory has given us some details of the method of attack.

DISCUSSION OF THE METHOD OF ATTACK

Microscopical examination of both living and sectioned material shows that the attack of plasmodia upon all of the sporophores examined to be both pathogenic and parasitic; pathogenic in that the plasmodium may cause necrosis of the living fungous tissues with which it comes in contact, and parasitic in that the fungous tissues are digested and then absorbed to furnish nutrients for the growth and activities of the plasmodium.

Pinoy (10) doubts that plasmodia have the power of digesting fungous mycelium. He believes that the breakdown of the fungous tissues is due to associated bacteria and to the water absorbing power of the plasmodium which is supposedly able to dry up and kill the mycelial filaments without digesting them. Some of the evidence found by the authors to oppose this view is: 1, living hyphae with no signs of bacteria surrounding them can actually be seen to dissolve throughout their length when covered by the plasmodium, 2, stained sections (Plate 48, figs. 6–7) have failed to reveal bacteria digesting the hymenial layer in order that the plasmodium might absorb the by-products, 3, a normally non-parasitic plasmodium after being allowed to move over a culture of bacteria or of yeasts, which have been found associated with an actively parasitic plasmodium, does not become mycophagous when given the opportunity to digest fungous material.

The process of destruction appears to be of a chemical nature, as is evidenced by observing the individual hyphae in contact with the plasmodium gradually lose their sharp outlines and become dissolved. The time required for the dissolution of the fungous tissue seems to vary with the digestive secretions of the plasmodium, but no special study of this digestive process was made. The nature of the hyphal wall appears to play an important role in susceptibility to plasmodial attack, as is shown by their attack on hyaline hyphae more readily than on colored ones. No microchemical tests of the hyphal walls have been made with which this specificity could be correlated. The thickness of the fungous wall likewise appears to be directly proportional to the length of time necessary for its digestion by the plasmodium, as is shown by thin-walled hyaline hpyhae of the hymenium actually dissolv-away within a few seconds after coming in contact with the advancing margin of the plasmodium, while thick-walled hyphae either may require several minutes for their dissolution and may be found several millimeters behind the advancing margin before they break down, or they are not digested but are left as debris.

In order to dispel any possible idea that digestion occurs in advance of the plasmodium, it is emphasized that the tissues to be digested must lie in close contact with the plasmodium. This contact, however, may be either with the surface membrane or with a vacuolar membrane. Although digestion of hyphae in vacuoles is a possibility, it could not be definitely demonstrated in stained preparations of plasmodia parasitising sporophores, but the hyphal tissues appeared to be digested without engulfment at the ventral surface of the plasmodium (Plate 48, fig. 5).

On the other hand spores appear to be more generally enclosed in vacuoles for digestion. An excellent example of the ingestion of spores was witnessed when sections of the plasmodium of *Physarum polycephalum* attacking the lamellae of *Hypholoma sublateritium* were examined (Plate 48, figs. 6–7). The smooth, oblong-elliptical, purple-brown spores, measuring 3–4 x 6–7 microns, may be clearly seen enclosed in vacuoles in the matrix of the plasmodium. In Plate 48, figs. 6–7, the spores are shown near the ventral surface of the plasmodium and the nuclei near the dorsal surface. The plasmodium is highly vacuolate in its ventral portion where it is assimilating nutrients. Very large, dark-colored, thick-walled spores are many times not ingested but merely pushed aside mechanically by the plasmodium.

Although Lister (8) and others report that fungous tissues, spores, and other solid ingesta are engulfed and move in the pro-

toplasmic currents of the plasmodium, the authors have found that the plasmodium feeding upon a sporophore carries on practically all of its digestion of hyphae and spores close to the advancing margin. Only occasionally what appears to be a bit of hypha or a spore may be seen coursing through the plasmodial strands back of the advancing edge.

A study of sections of the pileus of *Pleurotus serotinus* attacked by the plasmodium of *Physarum flavicomum* shows the gills becoming more and more eroded until there remains only a small shapeless mass of indigestible residue. In Plate 48, fig. 5 the basidial layer has completely disappeared and the tissues underneath the plasmodium are being dissolved. There is a sharp line of demarcation between the plasmodium and the fungus. As soon as the basidial layer is dissolved on one gill, the Myxomycete moves to that of the next.

SUMMARY

Attention is called to the ability of plasmodia of Myxomycetes to parasitise the fruitbodies of common wood-rotting fungi. Some species of Myxomycetes have been shown by field observations and laboratory tests to be very generally parasitic upon Hymenomycetes, while other species are moderately so, or as yet, non-parasitic. In the laboratory about eighty-five species of the Hymeniales, ranging from fragile fleshy Agarics to hard woody Polypores, were inoculated and most of them were found to be attacked by one or more of the thirty-three different plasmodia used in this study.

Plasmodia of the following species are now known to be mycophagous: *Badhamia foliicola*, *B. magna*, *B. rubiginosa*, *B. utricularis*, *Brefeldia maxima*, *Fuligo septica*, *Hemitrichia clavata*, *Leocarpus fragilis*, *Lycogala epidendrum*, *Physarum flavicomum*, *P. polycephalum*, *P. rigidum*, *P. tenerum*, *P. virescens*, and *Trichia decipiens*. Many other plasmodia, as yet unidentified, exhibited various degrees of parasitism. Unaccounted for preference for some fruitbodies is exhibited by the plasmodia. Mushrooms poisonous to man are readily parasitized by plasmodia, but the maturity of the sporophore does affect the parasitism of the Myxomycete.

The plasmodia bring about the destruction of the sporophores in two ways: 1, by actively digesting the sporophores themselves, and 2, by leaving the moist, slimy, injured fungous tissues, over which they have passed in an ideal condition for infection by bacteria and fungi which carry the destruction further.

The process of destruction of the sporophores is one of digestion, the basidial layer being usually the first tissue attacked. Hyphal tissues are digested at the highly vacuolate ventral surface of the plasmodium without enclosure within the vacuoles, while the spores are usually ingested and then digested within the vacuoles.

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EXPLANATION OF PLATES 48 AND 49

Fig. 1. Fruitbodies of *Collybia succosa* which had been inoculated with *Physarum polycephalum* twelve hours previously. The two sporophores on the left are held erect with pins due to destruction of their stipes by the plasmodium.

Fig. 2. Twenty-four hours later the plasmodium has reduced all of the fruitbodies to moist blue-black masses of tissue.

Fig. 3. Pore surface of *Polyporus Schweinitzii* being attacked by the plasmodium of *Physarum polycephalum*. × 8.

Fig. 4. The same pore surface after the plasmodium has passed over it. Note the thin pore walls left behind. × 8.

Fig. 5. Photomicrograph of gills of *Pleurotus serotinus* being attacked by the plasmodium of *Physarum flavicomum*, showing the manner in which the tissues are digested. Observe the sharp line of demarcation between the darkly stained plasmodium and the tramal tissue. Section cut 10 μ thick and stained with Flemming's triple. × 63.

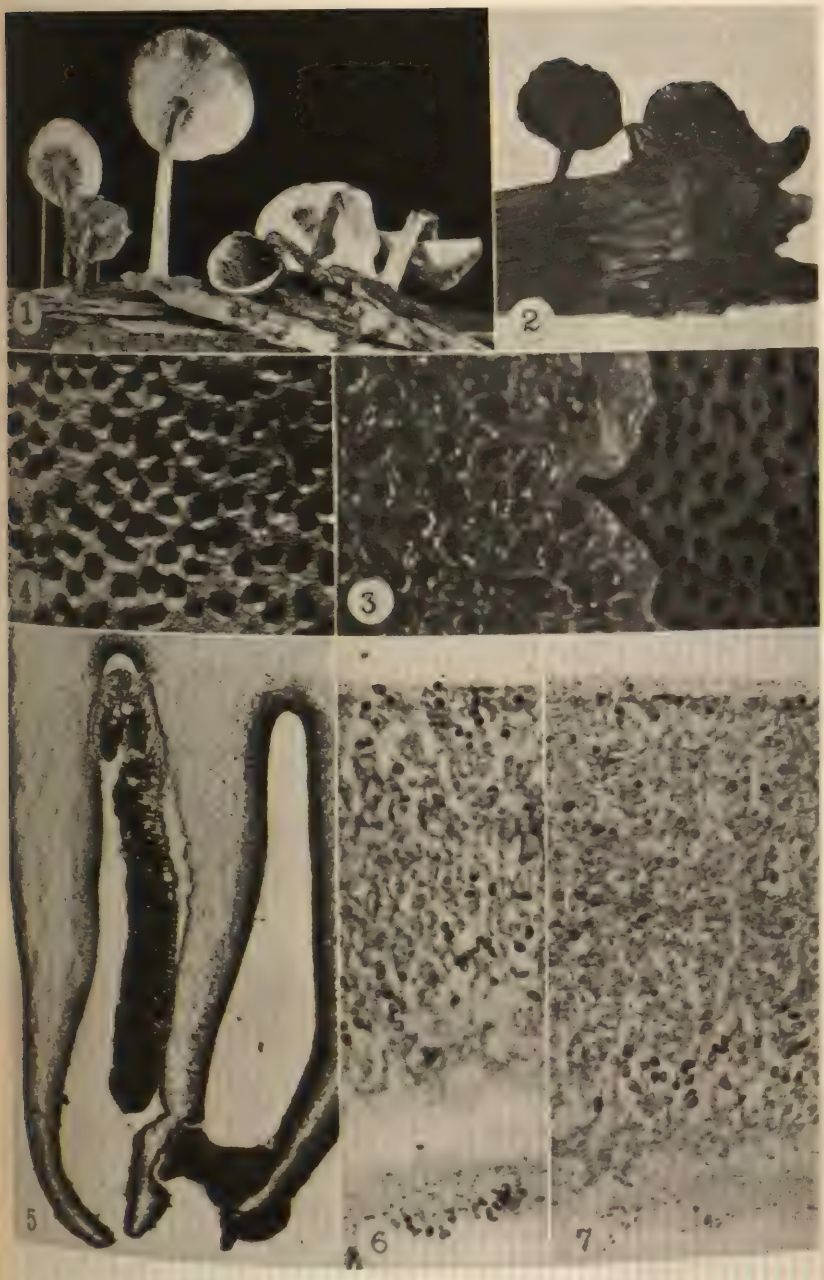
Fig. 6. Photomicrograph of the plasmodium of *Physarum polycephalum* shown digesting the hymenium and ingesting the spores from a gill of *Hypholoma sublateritium*. The trama and hymenial layer on one side of the gill has been digested but the hymenial layer on the other side of the gill is shown at the bottom of the picture. × 295.

Fig. 7. Photomicrograph of another portion of the plasmodium and gill shown in Fig. 6. Here is shown a bit of the trama at the bottom of the section, the dark colored spores ingested in the vacuolate ventral portion of the plasmodium, and the stained nuclei with their nucleoli which appear as bulls-eyes in the dorsal portion of the plasmodium. Paraffin section cut 3 μ thick and stained with iron-alum-haematoxylin. × 295.

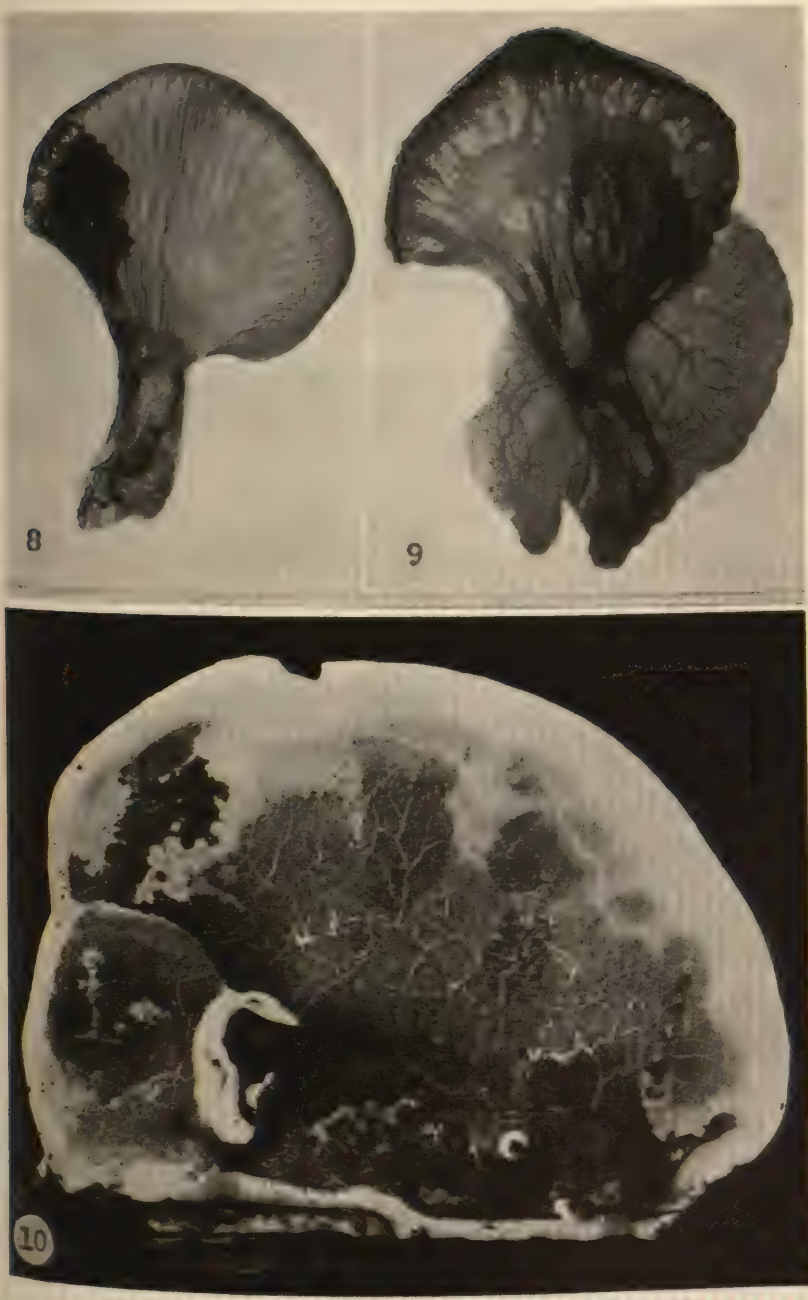
Fig. 8. *Pleurotus serotinus* inoculated with the plasmodium of *Physarum flavicomum*.

Fig. 9. Twenty-four hours later the plasmodium has destroyed the gills, leaving behind a moist, slimy surface ideal for the growth of bacteria and saprophytic fungi.

Fig. 10. A sporophore of *Fomes applanatus* twenty-four hours after being inoculated with the yellow plasmodium of *Physarum polycephalum*. The fluffy white surface layer of hyphae is being removed thus allowing the eroded brown pore surface to show through.



Parasitism of Plasmodia on Sporophores



Parasitism of Plasmodia on Sporophores

STUDIES ON THE PRECIPITIN REACTION IN PLANTS

II. PRELIMINARY REPORT ON THE NATURE OF THE "NORMAL PRECIPITIN REACTION"

KENNETH S. CHESTER

In 1928 Kostoff first called attention to the fact that the aqueous extracts of the foliage of certain Solanaceous plants precipitate in the presence of certain other such Solanaceous extracts (3). This precipitating action was designated as a "normal precipitin reaction," and the modification of such reactions after intergrafting underlies in part Kostoff's theory regarding acquired antibody production in such plants. In 1931 the writer published a record of his tests of the "normal precipitin reactions" in a number of species of the Oleaceae (1). These tests showed that the species of Oleaceae tested were in no case interreactive with the exception of numerous varieties of *Syringa vulgaris* which were suffering from a physiological blight due to graft incompatibility. Such varieties reacted strongly against a number of other Oleaceae including healthy, ungrafted plants of the same varieties as the reactive plants. Meanwhile Silberschmidt in Munich had also been studying the Kostoff phenomenon from the standpoint of technique. Silberschmidt has published an extended piece of research dealing mainly with improvements of the methods of extracting and testing (4), and he intended, at the time of publication, a continuation of his work dealing with the actual experimental results of his tests. Early in 1932 there appeared a second paper by the writer (2) showing that the "normal precipitin reactions" between species of the Rosaceae, Saxifragaceae, and Caprifoliaceae are well correlated with the systematic positions of the species considered.

Thus far little attempt had been made to determine the biochemical nature of the reaction. Kostoff and Silberschmidt both assume that the phenomena are of protein nature, and that they are analogous to the phenomena of animal serology. In 1932, however, the writer stated that: "Some of the reactions, such as those of *Prunus*, *Ribes*, and *Robinia*, lead one to the suspicion that possibly some non-specific compound is acting in a rather complex fashion to produce the precipitates" (2, page 71). The problem of the chemical nature of the "precipitin reaction" thus lay open to investigation and was of utmost importance in interpreting and evaluating the results of the earlier experiments. In the phytopathological laboratories of the Arnold Arboretum investigations have accordingly been in progress during the past

winter to determine the chemical nature of the precipitating property of the extracts. As these investigations have been fruitful and as the results are of importance in directing future activities in this field, the present paper is designed to give a condensed account of these results, while a more detailed description of the work will appear in an early number of this Journal.

In the fall of 1931 collections of leaves of certain species of woody plants were dried and pulverized. These relatively homogeneous stock supplies were used for all the tests of woody plants described below. The technique employed was in all important particulars the same as that previously described (2). Among the species selected were *Prunus Armeniaca* var. "Mikado," *Platanus acerifolia*, *Robinia fertilis*, and × *Ribes Carrierei*. Of these four the *Prunus* tests strongly against the other three which latter are mutually inter-negative. The results obtained from a study of these four species were later found to apply to extracts of *Hydrangea paniculata* var. *grandiflora*, *Syringa vulgaris*, *Ligustrum obtusifolium*, *L. ibota*, and *L. vulgare* var. *foliosum*. Finally, the findings were applied to thirty-five species of Solanaceae, and accordingly the results here recounted have been gained from a study of practically all of the possible inter-reactions of forty-four species of herbaceous and woody plants.

As a working hypothesis the theory was first entertained that the reactions might be of protein nature. Accordingly the earlier part of the investigation dealt with an analysis of the reactions on the basis of such an hypothesis. However, the results obtained from an analysis of the *Prunus-Robinia-Platanus-Ribes* reactions showed a very peculiar behavior if such an hypothesis were correct. The findings in this connection are here enumerated:

1. Variation in the salt content of the extracts by the use of Cohn's phosphate buffers at constant pH of 6.0 had very little effect on the reactive potency of *Prunus* between the limits of .06 M and 1.2 M. Between the same limits, however, there was a gradual fall in reactive potency of *Platanus* and *Robinia* from the weaker to the stronger salt concentrations.
2. Variation of the pH of the extracts by the use of Cohn's phosphate buffers at constant salt concentration of .06 M had no effect on *Robinia* between the limits of 5.2 and 8.4, and also no effect on *Prunus* between the same limits except for a sharp decline from 8.0 to 8.4 and from 5.6 to 5.2.
3. Long continued heating (even to three hours autoclaving at 5 lbs. pressure) did not decrease the reactive strength of either *Prunus* or *Robinia* extracts.

4. Precipitation of the extracts of *Prunus* or *Robinia* by excessive alkalinity or acidity, followed by filtration and subsequent neutralization did not remove the reactive principles.
5. There was no significant effect on the strength of the reaction if the pulverized leaves were thoroughly extracted with strong alcohol, anhydrous ether, benzol, or carbon tetrachloride as a preliminary to extraction with water.
6. There was no diminution in reactivity after storing the extracts at 2° C. for as much as four months. Even bacterial or fungous contamination had little or no effect on the strength or specificity of the reaction, when the extracts were subsequently cleared.
7. The progressive dilution of each of the extracts in turn showed an almost linear diminution in reactivity, the reaction disappearing in *Platanus* between dilutions of 1 : 256 and 1 : 512 and in *Prunus* between dilutions of 1 : 64 and 1 : 128. (*Note*: Normality of the extracts was arbitrarily chosen at 1 part dried tissue to 10 parts distilled water. The dilutions referred to here were further dilutions of such normal extracts.)
8. The reactivity of the extracts was unaffected by continued digestion with trypsin, pepsin, and yeast enzymes at appropriate pH values and temperatures.
9. Complete precipitation of *Prunus* by *Robinia*, *Platanus*, *Ribes*, or *Hydrangea* completely eliminated any further reaction of the thus-precipitated *Prunus* by any other of the latter four.
10. Fractionation of the extracts by the Rimington technique for removing carbohydrates showed that the reactive principle of *Prunus* was precipitated by neutral lead acetate and was entirely recoverable from that precipitate on treatment with H_2S. The reactive principles in *Robinia* and *Platanus*, on the other hand, were unaffected by treatment with both neutral and alkaline lead acetate and were completely recoverable in the nearly Molisch-negative filtrate from such treatment.
11. Extensive dialysis experiments showed that the reactive principles of *Prunus*, *Platanus*, and *Robinia* passed freely through membranes impermeable to formed proteins and only very slightly permeable to protein cleavage products. The strength of the reactive principles thus fractionated varied directly with the strength of chloride and carbohydrate (used as indices of the degree of dialysis) and bore no relation whatever to the strength of protein as indicated by the Millon and xanthoproteic tests (used as indices of the degree of dialysis).

Reviewing the evidence presented, the probability that the *Prunus-Platanus-Robinia-Ribes* reactions are due to proteins is

very slight. Although plant proteins are more resistant to heat than animal proteins and accordingly the results in heating the extracts are inconclusive by themselves, yet it is inconceivable that proteins would not be removed or inactivated by treatment with acids and alkalis and with alcohol, by salt content and pH, by contaminations and enzyme action, and by the removal of various constituents of the extracts as must be the case if proteins are here involved. The identity of the various reactions of these species (item 9 above) argues against the protein hypothesis, and finally the experiments in dialysis show that it is extremely unlikely that the reactions are due to extremely small traces of protein. The likelihood that these reactions are due to lipoids or to carbohydrates is also very dubious in view of the results given in items 5 and 10 respectively.

In the course of an experiment on hydrolysis of the extracts a small excess of $CaCO_3$ was added to a sulphuric acid solution of *Prunus*. On neutralization it was found that its precipitating action was completely reversed. The presence of the calcium sulphate thus formed, although only very slightly soluble in water, rendered the *Prunus* negative to *Platanus*, *Robinia*, and *Ribes*, and, as was later found out, positive to extracts with which it had formerly been negative. Attention was accordingly directed to the inorganic constituents of these extracts with particular reference to calcium compounds.

This last was a most productive field. It was soon discovered and confirmed that the reactions in the woody plants under consideration are due to the interaction of free calcium ion in certain extracts (in this case in *Robinia*, *Platanus*, and *Ribes*) with free oxalate ion in the other extracts (represented for the present by *Prunus*). Such a view has resulted both from chemical analyses of the precipitates and from studies of the behavior of the whole extracts with regard to presence or absence of calcium and oxalate. The analytical evidence supporting the view that these reactions are due to the interaction of such ions in first presented:

1. The precipites, after washing in several changes of water, are white, heavy, limey, easily centrifuged, and inorganic in appearance. There is no charring on heating to 500° C.
2. The precipitates microscopically are in the form of regular granules, not amorphous, identical in appearance with certain commercial samples of calcium oxalate.
3. Recrystallization of the precipitates (by solution in strong H_2SO_4 and precipitation by neutralization with strong KOH) gives crystals of the characteristic size and shape of CaC_2O_4

crystals, and indistinguishable from crystals of a commercial sample of CaC_2O_4 similarly treated.

4. Treatment of the granules of the precipitates with strong H_2SO_4 under the microscope shows first a moderate solution followed by a very striking conversion of the remainder of the granules into the characteristic raphides of $CaSO_4$. This is a fairly accurate test for CaC_2O_4 and is precisely the behavior of a sample of commercial CaC_2O_4 similarly treated.
5. The precipitates are insoluble in all ordinary solvents. They are moderately soluble in strong H_2SO_2 but not in weaker acids. Their solubilities are thus equivalent to those of CaC_2O_4.
6. If alcohol is added to the H_2SO_4 solution of the precipitates there is a precipitation. (Test for calcium ion.)
7. The acid solution reduces potassium permanganate. (Test for oxalates).
8. Ignition of the washed precipitate yields 33% of oxide. The theoretical yield for CaC_2O_4 is 38%.

The evidence thus given leaves no room for doubt that the precipitates resulting from the addition of the *Prunus* extract to those of *Platanus*, *Robinia*, and *Ribes* consist of calcium oxalate. This evidence is still further confirmed by experiments to be reported below. At this time, however, certain questions arise: (a) Is this calcium oxalate reaction the only one involved in the combinations of woody plants under consideration? (b) How generally is the calcium oxalate reaction distributed through plants with especial reference to the tests which have been reported in the literature? (c) Are other reactions also involved in the tests which have been reported, and if so, what is their nature? The answers to these questions will appear from the following considerations.

If the calcium oxalate reaction is the main or only reaction in the woody plants available for this study it should be possible to divide all the extracts into two groups, a calcium-positive, oxalate-negative group which is intranegative but positive to a second, oxalate-positive, calcium-negative group. Such is possible. *Prunus Armeniaca* "Mikado" is here the only representative of the "oxalate" group (containing oxalate, lacking calcium), while the "calcium" group comprises *Platanus*, *Ribes*, *Robinia*, *Syringa*, *Hydrangea*, and the three species of *Ligustrum*. With the exception of a very weak reaction to be mentioned later, the latter group is perfectly intranegative. On the other hand, the members of this "calcium" group all produce precipitates identical in appearance with the "precipitin reaction" when they are added to weak solutions of

oxalates ($K_2C_2O_4$ .01 M; $(NH_4)_2C_2O_4$ .02 M) but are inactive to the addition of weak solutions of calcium salts ($CaCl_2$ .005 M; $Ca(NO_3)_2$ .005 M). *Prunus*, however, reacts positively to pure solutions of calcium salts of the concentrations given above but is negative to these oxalates.

At this juncture it was felt advisable to extend these results to the Solanaceae for the dual purpose of obtaining more extensive data, and of obtaining data on the family on which the work of Kostoff and Silberschmidt has been done. Accordingly, all the possible interreactions of thirty-five species of Solanaceae as well as all their reactions with the woody plants under consideration were carried out by the writer in collaboration with Dr. Thomas Whitaker. The results of these tests were highly confirmatory. Testing the various Solanaceae against weak solutions of two oxalates and of two calcium salts it was found that the species fell into three groups, a group (Ca- Ox+) comprising *Atropa belladonna*, *Solanum tuberosum*, *Capsicum frutescens*, *Physalis peruviana*, *Salpiglossis sinuata*, *Datura ferox*, *D. metel*, and *D. innoxia* which were all positive in varying degree to the calcium salts and negative to the oxalates, a group (Ca- Ox-) comprising *Datura Wrightii*, *Cyphomandra betacea* and *Browallia viscosa* which were negative to both ions, and a group (Ca+ Ox-) comprising eighteen species of *Nicotiana*, *Petunia violacea*, *Lycopersicum cerasiforme*, *Solanum capsicastrum*, *S. melongena*, and *S. nigrum* which were negative to free calcium ion but positive to free oxalate ion. The extracts of group (Ca- Ox+) were positive to those in group (Ca+ Ox-) but those of group (Ca- Ox-) were negative to all in both other groups. Moreover the strength of the "precipitin reactions" bore a very close relation to the strength of the reactions of the corresponding extracts with the pure salt solutions. The (Ca- Ox+) group was perfectly negative *inter se* and the (Ca+ Ox-) group was also negative *inter se* except for a few weak reactions principally involving *Datura Wrightii* and *Nicotiana Rusbyi*. Thus a consideration of the Solanaceae affords very strong confirmatory evidence as to the validity of the calcium oxalate explanation.

A warning should be introduced at this point. The writer is well aware of the fluctuations of the salt content in plant juices and makes no contention that the values for the reactions are definite and always exactly reproducible. The readings will vary with the observer, with the technique, and with the environment and heredity of the plants investigated. However, that high developments of the content of such inorganic constituents are characteristic of certain species is evident from a consideration of

the literature. Moreover that the results here described are comparable is evident from the facts that the layerings and readings were all made by the same observer, that all the reactions described for any given species of plant in this study were made from one given extract, that the Solanaceae were all grown under uniform greenhouse conditions, and that all of the "precipitin" tests described were made within a few days of one other.

An important confirmation should now result from testing the "calcium" Solanaceous extracts against the woody "calcium" extracts. If the calcium oxalate explanation be correct and complete, then such reactions should all be negative. In order to extend the limits of this experiment still farther, all the "oxalate" extracts, woody and herbaceous, were treated with a slight excess of $CaCl_2$ and filtered. Hence the calcium oxalate reaction was completely eliminated from consideration. Then all the possible combinations of the 42 extracts were again tested. This experiment brought out a very important fact. There is a second reaction in which *Platanus*, *Robinia*, and *Ribes* show a varying degree of reactivity against all the Solanaceae. The reactions of *Platanus*, *Robinia*, and *Ribes* are so well correlated here that it is most probable that there is a single substance (A) present in these three extracts which reacts with a second substance (B) in the Solanaceae. *Prunus*, *Syringa*, *Ligustrum obtusifolium*, and *L. ibota* react against neither the (A+ B-) nor the (A- B+) groups and accordingly are assumed to contain neither reactive principle.

It is now possible to eliminate both the calcium oxalate and AB reactions from consideration by considering only the interreactions of the 39 oxalate-negative, A-negative extracts. If this group of interreactions be studied it is seen that the great majority are negative (87%). There are a few scattered weak reactions, however, principally involving *Nicotiana Rusbyi* and *Datura Wrightii*. Rearranging all the remaining extracts according to their strength of reaction against the similar *N. Rusbyi* and *D. Wrightii* we find again that the 39 extracts are divisible into three groups, a group (M+ N-) comprising *N. Rusbyi*, *D. Wrightii*, *Cyphomandra*, *Ligustrum ibota* (?), and *Prunus* (?) which are positive to a group (M- N+) containing the remainder of the species with the exception of *Browallia*, *Salpiglossis*, *Petunia*, *Syringa*, *Ligustrum vulgare*, and *Solanum nigrum* (M- N-) which are negative to both groups.

There still remain a very few weak reactions (2%) which may be interpreted as due to a substance (X) present in *Solanum capsicastrum*, *Atropa*, *Physalis*, *Datura innoxia*, and *D. metel*

which reacts with a substance (Y) present in the Oleaceae studied, in *Browallia*, and in *Nicotiana suaveolens*, but absent in the other remaining extracts

These four reactions, the first proven, the second and third assuredly present and distinct but of unknown nature, and the fourth more problematical, since it is very weak, explain all of the thousand or fifteen hundred reactions considered in this study. Of all the positive reactions at least 57% are due to the calcium oxalate combination, approximately 23% to the AB reaction, 17% to the MN reaction, and less than 3% to the XY reaction.

We are now in a position to return to the questions propounded above. First, with regard to the presence of any other reaction in the *Prunus-Platanus-Robinia-Ribes* complex, we may say definitely that there is no other "precipitin" reaction demonstrable by the technique employed than the calcium oxalate reaction. Removal of the calcium oxalate reaction leaves these four extracts perfectly internegative. Second, as to the distribution of the calcium oxalate reaction among the experimental plants heretofore studied it may be said with certainty that this reaction is of wide distribution, that it accounts for the majority of the reactions of the plants used by Kostoff, and that it must be eliminated before any immunological interpretation can be made of the data thus far published. Kostoff published a table of "normal precipitin reactions" in the Solanaceae which includes 56 positive reactions. 40 of these have been repeated in this laboratory. Of the 40 repetitions, in 7 cases there were no positive results, in 10 cases the reactions were due to the MN combination, and in 23 cases the reactions were due to calcium oxalate. Kostoff reported acquirement of "precipitin potency" in 12 instances. The normal reactions as repeated in this study show that of the 8 repetitions 3 reactions were due to calcium oxalate, 3 were due to the MN reaction, and in 2 cases no positive results were obtained. Kostoff found a decrease of "precipitin potency" in 4 cases. 3 of these have been repeated and in all 3 cases the normal reactions were found to be due to the MN combination.

Third, as regards the presence and nature of other reactions in the plants considered, it may be said with certainty that there is at least one other reaction present, probably two, and possibly three or more. The nature of these other reactions is being investigated. For the time being, it may merely be said that with regard to the AB and MN reactions they are indubitably organic in nature since the washed precipitates are strongly charred on ignition. The precipitates of these reactions are very different in

appearance from the calcium oxalate precipitate. They are brown in color, even after washing, are copious and flocculent, and easily pass into a non-filterable colloidal suspension in pure water.

As further proof of the presence of more than one reaction, instances may be mentioned in which given extracts may be precipitated thoroughly to remove the calcium oxalate factor. Such calcium oxalate free extracts have lost none of their potency for precipitating in the presence of the opposite principle of the AB or MN reactions.

A word should be inserted at this point regarding the expressions "calcium" extracts, "oxalate" extracts, etc., frequently used in the foregoing pages. Such expressions do not imply that certain *plants* are free from demonstrable oxalate or calcium respectively, since the extracts used reveal the *excess* of either ion after such autoprecipitation of CaC_2O_4 as may take place in preparing the extracts. It is very apparent, for example, that *Prunus Armeniaca* vars. "Mikado" and *ansu* fall into the "oxalate" class not because they lack calcium but because they contain more than sufficient oxalate to neutralize the calcium normally present in the leaves.

With regard to the interpretation of the writer's earlier experiments in the light of the present findings, two questions arise: (a) Is the reaction of graft-blighted Lilac toward healthy Oleaceae (1) susceptible to explanation according to the calcium oxalate interpretation? (b) What light do the present findings throw on the specificity of the reactions as found in the Rosaceae et al. (2)? Both of these questions are readily understood by the results of the present paper.

In the first place, normal Lilac, and indeed the other species of Oleaceae studied, are all "calcium" plants, i. e. their extracts contain an excess of Ca^{++} ion. During the actual dying of the leaves of blighted Lilac there is an accumulation of oxalic acid or an oxalate in the affected cells. That this is not generally distributed throughout the plant (as would be true of an immunological substance resulting from grafting) is shown by the fact that the extracts made from green areas of mottled green-and-yellow leaves (blighted) test just as do normal leaves of ungrafted plants. The accumulation of free oxalate in the blighted portions of the leaves is in harmony with the fact that such leaves when ground and mixed with water begin an autoprecipitation (of the calcium normally present in the leaf by the oxalate) which if permitted to be carried to the end results in an excess of unused oxalate which gives the reaction with the other Oleaceae previously described. Immediately after maceration of the leaves, however, both oxalate and calcium can be demonstrated in the extracts.

Regarding the second question, as to the specificity of the reactions thus far observed, light was thrown upon this phase of the work by a consideration of the distribution of free calcium ion, free oxalate ion, and the other reactive principles in these various species of plants studied. On purely *a priori* grounds it would not be unreasonable to expect that in general the distribution of such substances would show some agreement with the taxonomic relationships of the plants involved. Thus it is well known that the presence or absence of calcium oxalate crystals in plant cells is of taxonomic significance. How does this apply to the Solanaceae and woody plants here studied? A dendritic chart was made including all the possible combinations of reactive substances believed to be responsible for the reactions observed. Thus the chart would first include a trifurcation representing presence of free calcium or free oxalate or absence of both. Each subdivision could then be further trifurcated according to presence or absence of the A and B principles, etc. There would thus be 81 possible combinations of reactive principles represented. If the assumption of specificity be correct, there should be a definite tendency for related species to have related positions on such a chart. The actual placement of the various species in their proper positions on such a chart brought out the validity of this assumption in striking clearness. 18 species of *Nicotiana* had been studied. All contain free calcium but not free oxalate, all contain the principle B but lack the principle A, *N. Rusbyi* alone contains the principle M, the other 17 species all contain N, while all the species of *Nicotiana* save *N. suaveolens* lack both X and Y. The possibility of their being so constituted by chance is infinitesimal. Similarly the Oleaceae considered are closely allied in all containing Ca^{++}, all lacking principles A and B except *L. vulgare* which has only a trace of this, all lacking both X and Y, and separating only with regard to the presence or absence of M and N. *Robinia*, *Platanus*, and *Ribes*, in closely related families, all are found to lie in the same quarter of the dendritic system, being all positive for calcium and for principle A, they being the only representatives of the A principle in the whole scheme. So, too, the 4 species of *Datura* as well as those of *Solanum* are found to agree in three of the four reactive principles, separating on only one.

It is thus seen that the distribution of the reactive principles in the 42 species of plants here considered is in good accordance with the taxonomic positions of these species, which clearly explains the earlier findings, before the nature of the reactions had been investigated, with regard to the specificity exhibited by the reaction.

SUMMARY

1. The present paper gives a condensed account of the writer's investigations of the biochemical nature of the "normal precipitin reaction" in plants.
2. Extensive experiments in the testing of various physical and chemical treatments have yielded strong evidence against the hypothesis that the reaction in certain woody plants, viz. *Prunus Armeniaca*, *Platanus acerifolia*, *Robinia fertilis*, and *Ribes Carrierei*, is of protein nature.
3. Conclusive proof is given that the reaction resulting in approximately 57% of the precipitates observed in all the possible combinations of 42 species of Solanaceous and woody plants is the precipitation of calcium oxalate by the interaction of the respective ions in pairs of extracts. This precipitation of calcium oxalate is so frequently the sole or main phenomenon in the reactions hitherto considered immunological in nature as to invalidate immunological interpretations laid on such reactions in which the calcium oxalate factor is not eliminated.
4. The remaining reactions are susceptible to interpretation on the assumption of the presence or absence of three other pairs of reactive substances. The nature of these reactive pairs is relatively obscure at present, but it is being investigated. One such pair (AB) is particularly characterized by the reactions of oxalate-free *Robinia*, *Platanus*, and *Ribes* with the Solanaceae. This reaction accounts for about 23% of the positive precipitations. It is shown to be distinct from the calcium oxalate reaction. A second pair (MN) is represented by the reactions of oxalate-free and AB-free *Nicotiana Rusbyi* and *Datura Wrightii* with most of the other Solanaceae. It is plainly distinct from the calcium oxalate and AB reactions and accounts for about 17% of the precipitations. A very small residue of reactions (less than 3%) is finally explained by the assumption of a last pair of reactive substances XY, the reactions being represented by those of *Solanum capsicastrum*, *Atropa belladonna*, *Physalis peruviana*, *Datura innoxia*, and *D. metel* against certain Oleaceae.
5. The writer's earlier findings with regard to "precipitin reactions" of physiologically blighted Lilac and to the specificity of the "normal precipitin reaction" are readily interpreted on the basis of the findings of the present study.

Acknowledgement is due for the many suggestions and freedom of his laboratory given the writer by Dr. Ronald Ferry of the Har-

vard Medical School, and to Dr. Thomas Whitaker who coöperated in the testing of the Solanaceae. The writer is also indebted to Professor E. M. East for placing the Solanaceae at his disposal and to Professor J. H. Faull for numerous helpful suggestions.

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NOTES ON SOME CHINESE PLANTS

FRANKLIN P. METCALF

Hydrangea Chungii Rehder in Jour. Arnold Arb. XII. 69 (1931). In the original description of this species the collector's numbers of the type and paratype were unfortunately omitted. These data are supplied below as well as additional records seen by the author.

FUKIEN: Yenping, Fort No. 3800, alt. 230 m., August 21, 1924, *H. H. Chung*, no. 3043 (holotype at the Arnold Arboretum, 2 sheets, one from University of California; isotype seen at Kew and Amoy); Yenping, Buong-kang, alt. 200–1000 m., June 8, 1925, *H. H. Chung*, No. 3260 (paratype at the Arnold Arboretum, also seen at Amoy); Yenping, Buong-kang, *S. T. Dunn*, Fukien Expedition, 1905, Hongkong Herb. no. 2663, also is this species (seen at Kew and Hongkong) as well as *S. T. Dunn*, Hongkong Herb. No. 2678, without data (seen at Hongkong).

Another specimen collected in 1909 by Schindler in "Südwest Fukien, Feng Yuan Ch'iao, im Kreise Shang-hang, 750 m., *Schindler* A 19" (Schindler Herb., Berlin) may also represent this species. It was seen by the writer in 1928, but unfortunately could not be identified, as it did not match any species then known. This species evidently has a very local distribution.

Tarenna mollissima (Hook. & Arn.) Merrill in Phillip. Jour. Sci. XIII. Bot. 160 (1919).

Cupia mollissima Hooker & Arnott, Bot. Beechey Voy. 192 (1833).

Stylocoryne mollissima Bentham, Fl. Hongkong. 156 (1861).

Webera mollissima Bentham in Dunn & Tutcher, Fl. Kwangtung, 130 (1912).

Tarenna incana Diels in Notizb. Bot. Gard. Mus. Berlin, IX. 1032 (1926).—**Synon. nov.**

Tarenna vestita Diels in sched.—**Synon. nov.**

Of the species *T. incana* Diels there is available at the Arnold Arboretum not only the isotype, but also a photograph and fragments of the type. Of *T. vestita* Diels, which was apparently never published but distributed under this name, there are two collections, H. H. Hu, nos. 1144 and 1281, both from Kiangsi. The first species represents fruiting and the latter flowering material of the common but variable species *T. mollissima* Merrill. The characters chosen by Diels (l. c.), namely, shape at base of leaves, laxness of inflorescence, and degree of indumentum, are extremely variable; leaves showing bases that are subrotund, or obtuse, or broad-cuneate, to narrow cuneate can be found on the same branch. The rest of his description also agrees very well with *T. mollissima* Merrill.

SPECIMENS SEEN. Chekiang: *Keng*, 88, 243, 863; *Ching* 1979; *Hu*, 538, as *T. incana* Diels, isotype; also photo and fragment of type.—Fukien: *Chung*, 2236, 2316, 2828; *Uong*, FCU 12091.—Kiangsi: *Hu*, 1281 and 1144, as *T. vestita* Diels, isotype.—Kwangtung: *Mell*, 75, 666; *Tsiang* 830, 1562, 2636; *Levine*, 78; *Chun* 5561.—Hongkong: *Tsiang*, 652; *Ford; Chun*, 5097.

Viburnum Smithii Metcalf, nom. nov.

Viburnum parvifolium W. W. Smith in Notes Bot. Gard. Edinb. x. 76 (1917).—Non *V. parvifolium* Hayata.

As there is already a *Viburnum parvifolium* Hayata in Jour. Coll. Sci. Tokyo, xxx. 134 (1911) published 6 years earlier, the species described under the same name by W. W. Smith must be renamed.

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A PREVIOUSLY UNDESCRIBED VARIETY OF LORANTHUS VITELLINUS F. v. MUELL. FROM NORTH QUEENSLAND

W. F. BLAKELY

Loranthus vitellinus F. v. M. var. **inflata**, var. nov.

Varietas foliis coriaceis oblongo-ovatis vel ellipticis breviter petiolatis 4–6 cm. longis 2–3 cm. latis, racemis gracilibus brevibus, floribus rubris 3–6 in racemo, gemmis plus minusve lepidotis sub petalis valde inflatis.

Young parts and racemes covered with a ferruginous tomentum, as in the species. Leaves coriaceous, rather thick, oblong-ovate to elliptic, obtuse, shortly petiolate, 4–6 x 2–3 cm. Racemes slender, short, 3–6-flowered; flowers bright red, buds slightly scurfy, much inflated below the junction of the petals when fully mature.

This new variety differs from the typical form mainly in the shorter leaves and the brighter red and more inflated corolla. The latter character somewhat resembles that of *L. dictyophlebus* F. v. M.

Gadgarra Reserve, Atherton Tableland, *S. F. Kajewski*, no. 1163 (Arnold Arb. Exped.), July 27, 1929 (a common parasite on rain-forest trees; flowers a very pretty red, with a slight yellow ring below the stamens.)

BOTANIC GARDENS, SYDNEY,
NEW SOUTH WALES, AUSTRALIA.

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NOTES ON THE LIGNEOUS PLANTS DESCRIBED BY LÉVEILLÉ FROM EASTERN ASIA[1]

ALFRED REHDER

ROSACEAE

Neillia sinensis Oliv. f. **glanduligera** (Hemsl.), f. nova.

Neillia sinensis Oliv. var. *glanduligera* (Hemsley in herb.

Neillia glandulocalyx Léveillé, Fl. Kouy-Tchéou, 348 (1915).

A typo differt tubo calycis glandulis longe setoso-stipitatis instructo.

CHINA. Hupeh: without precise locality, *A. Henry*, no. 5554a (type of *N. sinensis* var. *glanduligera*). Kweichou: route de Pin-fa à Tou-yun, *J. Cavalerie*, no. 2461, July 1905 (holotype of *N. glandulocalyx;* merotype in A. A.).

This form seems almost as common as the typical form with glabrous calyx and the following specimens are referable to it: Shensi: "monte Thae-pei-san," *J. Giraldi*, July 20, 1897; Hupeh: without special locality, *E. H. Wilson*, Veitch Exp. no. 701 in part; (fruiting branch only); Ichang, *E. H. Wilson*, Arnold Arb. Exp. no. 86 in part (fruiting branches only); Hsing-shan hsien, *E. H. Wilson*, no. 189; Hunan: in monte Yun-schan prope urbem Wukang, *H. Handel-Mazzetti*, no. 12010.

Spiraea media Schmidt var. **monbetsusensis** (Franch.) Cardot apud Nakai in Tokyo Bot. Mag. XLII. 464 (1928).

Spiraea Fauriei Léveillé in Fedde, Rep. Spec. Nov. VIII. 281 (1910).—**Synon. nov.**

SAGHALIN: in rupibus littoris Kornakoff, *U. Faurie*, no. 575, July 1908 (holotype of *S. Fauriei;* photo. of type and isotype in A. A.).

In a note on the sheet of the type specimen Koidzumi has already identified *S. Fauriei* with *S. monbetsusensis* Franch., and Faurie no. 575 is cited by Nakai (l. c.) under the specimens from Korea but the name given by Léveillé is not mentioned.

[1] Continued from vol. XII. 281 (1931); for preceding parts see X. 103–132. 184–196.

Spiraea Martini Léveillé in Fedde, Rep. Spec. Nov. IX. 321 (1911); Cat. Pl. Yun-Nan, 244 (1917).—Rehder in Jour. Arnold Arb. I. 258 (1920)

Spiraea fulvescens Rehder in Sargent, Pl. Wilson. I. 439 (1913).

CHINA. Yunnan: environs de Yun-nan-sen, dans la montagne, ravines, bords de torrents, *E. Bodinier*, no. 89, March 2, 1897 (holotype of *S. Martini;* merotype and photo. in A. A.); Mengtze, barren clay hills, alt. 5000 ft. *A. Henry*, no. 10662 (holotype of *S. fulvescens* in A. A.).

Spiraea Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. IX. 321 (1911); Fl. Kouy-Tchéou, 301 (1915).

CHINA. Kweichou: district de Tou-chan, *J. Cavalerie* in herb. Bodinier, no. 2602, March–April 1899 (holotype; photo. in A. A.).

This species is closely related to the preceding and both may be forms of one species. It differs from *S. Martini* in the distinctly ovate leaves rounded at base, crenate and not at all lobed, less glaucous beneath, in the larger inflorescence with about 10 or more flowers and an elongated rhachis about 1 cm. long; in the larger flowers about 8 mm. across, in the slenderer pedicels up to 1.2 cm. long, and in the small leaflets at the base of the inflorescence being absent or reduced to very small bracts.

Spiraea pubescens Turczaninow in Bull. Soc. Nat. Moscou, V. 190 (1832).

Spiraea ouensanensis Léveillé in Fedde, Rep. Spec. Nov. VII. 197 (1909).—**Synon. nov.**

KOREA: in montibus Ouen-san, *U. Faurie*, no. 315, July 1906 (holotype of *S. ouensanensis;* photo. and isotype in A. A.).

An isotype of Faurie's no. 315 in this herbarium has the leaves broader and less pubescent and is just past flowering, while the type in the Edinburgh herbarium has leaves more like typical *S. pubescens* and is in fruit. Nakai (Tokyo Bot. Mag. XLII. 465, 466. 1928) distinguishes two forms, var. *lasiocarpa* and var. *leiocarpa;* the former seems to be the more common and *S. ouensanensis* belongs to it.

Spiraea ovalis Rehder in Sargent, Pl. Wilson. I. 446 (1913).

Spiraea microphylla Léveillé in Bull. Géog. Bot. XXV. 44 (1915); Cat. Pl. Yun-Nan, 244 (1917).—**Synon. nov.**

CHINA. Yunnan: rochers des montagnes à Kiao-mé-ti, alt. 3150 m., *E. E. Maire*, May 1912 (holotype of *S. microphylla;* merotype in A. A.).

This species was known so far only from the type specimen collected in Fang Hsien, Western Hupeh.

Spiraea Veitchii Hemsley in Gard. Chron. ser. 3, XXXIII. 258 (1903).

Spiraea atemnophylla Léveillé in Bull. Géog. Bot. XXV. 44 (1915); Cat. Pl. Yun-Nan, 244 (1917).—**Synon. nov.**

CHINA. Yunnan: rochers des montagnes à Kiao-mé-ti, 3200 m., *E. E. Maire*, Aug. (syntype of *S. atemnophylla;* photo. in A. A.); brousse de mamelon à Ta-hai, *E. E. Maire* (ex Léveillé; syntype of *S. atemnophylla*); pâturages du haut plateau de Ié-ma-tchouan, 3200 m., *E. E. Maire* (ex Léveillé; syntype of *S. atemnophylla*).

This species does not seem to have been recorded from Yunnan before.

Spiraea Mairei Léveillé in Bull. Géog. Bot. XXV. 43 (1915); Cat. Pl. Yun-Nan, 244 (1917).

CHINA. Yunnan: brousse des montagnes à Kiao-mé-ti, 3100 m., *E. E. Maire*, May 1912, "arbuste fragile, buissonant; fleurs blanches" (holotype; merotype in A. A.).

This species is very similar to *S. Teniana* Rehd. in its inflorescence and the shape and serration of the leaves, but differs in the striped or slightly angled villous branchlets, in the leaves being pubescent on both sides with long accumbent hairs, in the longer more villous pubescence of the inflorescence and the pubescent sepals.

Spiraea japonica L. f. var. **acuminata** Franchet in Nouv. Arch. Mus. Paris, sér. 2, VIII. 218 (Pl. David. II. 36) (1885).

Spiraea Bodinieri Léveillé in Fedde, Rep. Spec. Nov. IX. 322 (1911); Fl. Kouy-Tchéou, 361 (1915).—**Synon. nov.**

Spiraea Bodinieri var. *concolor* Léveillé, l. c. (1911).—**Synon. nov.**

Spiraea Esquirolii Léveillé, l. c. (1911); l. c. (1915).—**Synon. nov.**

CHINA. Kweichou: Mont du Collège, *E. Bodinier*, July 3, 1900 (syntype of *S. Bodinieri;* photo. in A. A.); environs de Touchan, *J. Cavalerie*, no. 2682, June 1899 (syntype of *S. Bodinieri*); mont de Lou-hong-koan, *E. Bodinier*, no. 1709, June 10 and July 21, 1897 (syntypes of *S. Bodinieri* var. *concolor* photos. in A. A.); Yang-tien, *E. Bodinier*, no. 492, (not 429) July 16, 1900, "arbuste; fleur violacé" (syntype of *S. Esquirolii;* merotype in A. A.).

There is no specimen of *S. Bodinieri* with the data "Mont du Collège, Juillet 3, 1900, E. Bodinier" in the Léveillé herbarium, but by elimination it must be the sheet labeled in Léveillé's handwriting *Spiraea Bodinieri* without any further data.

Spiraea Bodinieri var. *concolor* is not mentioned in Flore de Kouy-Tchéou, but its type number is cited under *S. Bodinieri;* nor does the varietal name appear on his type specimens.[1]

[1] *Spiraea holorhodantha* Léveillé in Bull. Geog. Bot. XXV. 44 (1915) is *Rodgersia pinnata* Franch. as determined by W. Edgar Evans in herb. Edinb.

Cotoneaster horizontalis Decaisne in Fl. des Serres, XXII. 168 (1877).

Diospyros Chaffanjoni Léveillé in Fedde, Rep. Spec. Nov. XII. 101 (1913); Fl. Kouy-Tchéou, 145 (1914).—**Synon. nov.**

CHINA. Kweichou: Kouy-yang, cascade du Collège, *Chaffanjon*, May 12, 1928 (holotype of *Diospyros Chaffanjoni;* photo. in A. A.).

Léveillé compares his *Diospyros Chaffanjoni* with *D. vaccinioides* Lindl. to which it has a very slight resemblance only in the shape of the leaves, but the latter are considerably larger in *D. vaccinioides*.

Cotoneaster Franchetii Bois in Rev. Hort. 1902, p. 379, fig. 159–161, 164.

Cotoneaster Mairei Léveillé in Bull. Géog. Bot. XXV. 45 (1915); Cat. Pl. Yun-Nan, 229 (1917).—**Synon. nov.**

Cotoneaster Mairei var. *albiflora* Léveillé, l. c.—**Synon. nov.**

CHINA. Yunnan: rochers des montagnes derrière Tong-tchouan, 2600 m., *E. E. Maire*, June 1912 (holotype of *C. Mairei;* photo. in A. A.); rochers des collines à Kin-tchong-chan, 2550 m., *E. E. Maire*, May 1912, "arbuste dressé buissonant; fleurs blanches sur calyce rouge" (holotype of *C. Mairei* var. *albiflora;* merotype in A. A.).

Var. *albiflora* differs only slightly in its smaller leaves and pure white flowers from typical *C. Mairei;* the color of the flowers varies in most species of this group from pure white to more or less flushed with pink in bud and on the back of the petals. The varietal name is not mentioned in the Catalogue des plantes du Yun-Nan and does not appear on the label of the specimen from Kin-tchong-chan.

Cotoneaster glaucophylla Franchet, Pl. Delavay. 222 (1890).

Photinia rosifoliolata Léveillé in Bull. Géog. Bot. XXIV. 142 (1914); Fl. Kouy-Tchéou, 349 (1915).—**Synon. nov.**

CHINA. Kweichou: Tin-fan, *J. Cavalerie*, no. 3838, June 1909, "fleurs blanches" (holotype of *Photinia rosifoliolata;* merotype in A. A.).[1]

Crataegus scabrifolia (Franch.) Rehder in Jour. Arnold Arb. XII. 71 (1931).

Crataegus Henryi Dunn in Jour. Linn. Soc. XXXV. 494 (1903).

Crataegus Bodinieri Léveillé in Bull. Soc. Bot. France, LV. 57 (1908).—**Synon. nov.**

CHINA. Yunnan: montagnes entre Ma-kay et Se-tsong-chou, *E. Bodinier*, April 4, 1897 (holotype of *C. Bodinieri;* merotype

[1] *Cotoneaster Blinii* Léveillé (Cat. Pl. Yun-Nan, 229. 1917) and *C. Esquirolii* Léveillé (Fl. Kouy-Tchéou, 345. 1915) do not belong to *Cotoneaster*, but the incomplete material does not allow to place them definitively. They may be conspecific and belong to the Pomoideae, resembling somewhat *Photinia* or *Stranvaesia*, but differing from them in the structure of the fruit, immature in *C. Esquirolii*.

in A. A.); Ma-chou, alt. 3000 m., *E. E. Maire*, April 1911–13 (in herb. Léveillé sub *C. Bodinieri*).

Both specimens are in bloom, while the type of Franchet's *Pirus scabrifolia* is in fruit.

Crataegus cuneata Siebold & Zuccarini in Abh. Akad. Münch. 2, IV. 130 (Fl. Jap. Fam. Nat. I. 22) (1846).

Crataegus Argyi Léveillé & Vaniot in Bull. Soc. Bot. France, LV. 57 (1908). —Léveillé in Mem. Acad. Ci. Art. Barcelona, ser. 3, XII. no. 22, p. 19 (1916).

Crataegus stephanostyla Léveillé & Vaniot, l. c. (1908).—Léveillé, l. c. (1916).

Crataegus Chantcha Léveillé in Fedde, Rep. Spec. Nov. X. 377 (1912); Fl. Kouy-Tchéou, 346 (1915).

China. Kiangsu: Chang-li-hong, Chang-sun, Vou-né, *Ch. d'Argy* [1846–66] (holotype of *C. Argyi;* photo in A. A.); Si-tcha-chun, Si-souo-se; Zi-se, montagnes, *Ch. d'Argy*, May 15 [1846–66] (holotype of *C. stephanostyla*); merotype in A. A.). Kweichou: environs de Gan-pin, *E. Bodinier*, April 29, 1897 (holotype of *C. Chantcha;* photo. in A. A.).

The specimens of *C. stephanostyla* and *C. Chantcha* are in bloom and that of *C. Argyi* is in fruit. All three represent undoubtedly the widely distributed and characteristic *C. cuneata* Sieb. & Zucc.

Crataegus pinnatifida Bunge in Mém. Acad. Sci. St. Pétersb. II. 100 (Enum. Pl. Chin. Bor. 26) (1831).

Crataegus coreanus Léveillé in Fedde, Rep. Spec. Nov. VII. 197 (1909).

Crataegus pinnatifida Bge. var. *psilosa* Schneider in Ill. Handb. Laubholzk. I. 769 (1906).—Nakai, Fl. Sylv. Kor. VI. 59, t. 26, fig. a (1916).

Korea: circa Seoul communis, *U. Faurie*, no. 307, June 1906, and circa Chinnampo, *U. Faurie*, no. 308, Sept. 1906 (syntypes of *C. coreanus;* isotypes and merotype in A. A.).

Crataegus coreanus has been already identified by Nakai (l. c.) with *C. pinnatifida* var. *psilosa* Schneid., but this identification is true only as far as it concerns Faurie's no. 307, while no. 308 which is in fruit belongs to the typical form (var. *typica* Schneid. l. c.). The two forms differ only in their glabrous or pubescent inflorescence; they are hardly of varietal rank and do not occupy distinct geographical ranges.

Sorbus Koehneana Schneider in Bull. Herb. Boissier, sér. 2, VI. 316 (1906).

Sorbus Valbrayi Léveillé in Monde Pl. sér. 2, XVIII. 28 (1916); Cat. Pl. Yun-Nan, 242, fig. 62 (1917).—**Synon. nov.**

China. Yunnan: plateau du Io-chan, 3400 m., *E. E. Maire*, June 1912, "grand arbuste rameux" (holotype of *S. Valbrayi*).

Sorbus Keissleri (Schneid.) Rehder in Sargent, Pl. Wilson. II. 269 (1915).

Sorbus Mairei Rehder & Léveillé apud Léveillé, Cat. Pl. Yun-Nan, 242 (1917), nomen.—**Synon. nov.**

Sorbus Aria var. *Mairei* Léveillé, Cat. Pl. Yun-Nan, 242 (1917), pro synon. *Sorbi Mairei.*

CHINA. Yunnan: rochers des montagnes à Kiao-mé-ti, alt. 3100 m., *E. E. Maire*, "arbuste buissonant, haut 1 m. ou 2 m." (holotype of *S. Aria* var. *Mairei;* photo. in A. A.).

Léveillé cites (l. c.) "*S. Aria* Crantz var. *Mairei* Lévl. in Fedde Rep. III. 341," but neither there nor elsewhere did I find this name, though it appears on the label of the type specimen. I may have written to Léveillé with whom I corresponded at that time, that his *Sorbus Aria* var. *Mairei* did not belong to *S. Aria*, but I had no part in making the combination *S. Mairei.*

Sorbus Hemsleyi (Schneid.) Rehder in Sargent, Pl. Wilson. II. 276 (1915).

Pirus Koehnei Léveillé in Fedde, Rep. Spec. Nov. x. 378 (1912); Fl. Kouy-Tchéou, 351 (1915); non *Pyrus Koehnei* Schneid. (1906).—**Synon. nov.**

CHINA. Kweichou: Pin-fa, montagnes, *J. Cavalerie*, no. 2376, June 15, 1905 (ex Léveillé; syntype of *Pirus Kochnei*); *J. Esquirol*, no. 385 (syntype of *Pirus Koehnei;* photo. in A. A.).

Photinia villosa (Thbg.) De Candolle, Prodr. II. 631 (1825).

Pirus brunnea Léveillé in Fedde, Rep. Spec. Nov. x. 377 (1912).—Rehder in Sargent, Pl. Wilson. II. 300 (1915).

Pirus sinensis Lindl. var. *Maximowicziana* Léveillé l. c. (1912).—Rehder, l. c. (1915).—**Synon. nov.**

Pirus spectabilis Ait. var. *albescens* Léveillé, l. c. (1912).—Rehder, l. c. (1915).

Pourthiaea villosa (Thbg.) Decne. var. *typica* (Schneid.) Nakai, Fl. Sylv. Kor. VI. 28 (1916).

Pourthiaea villosa var. *brunnea* (Lévl.) Nakai l. c. 29, t. 7 (1916).

KOREA. Quelpaert: in silvis Hallaisan, 800 m., *E. Taquet*, no. 2819, Oct. 1909 (holotype of *Pirus brunnea;* merotype and isotype in A. A.); in silvis Haitchenam [?], *E. Taquet*, no. 2821, Aug. 1909 (holotype of *Pirus sinensis* var. *Maximowicziana;* photo. and isotype in A. A.); in silvis Hallaisan, 900 m., *E. Taquet*, no. 2815, June 1909 (holotype of *Pirus spectabilis* var. *albescens;* photo. and isotype in A. A.).

Pirus brunnea does not seem to be sufficiently different from typical *Photinia villosa* to consider it a distinct variety as done by Nakai, while he refers *Pirus spectabilis* var. *albescens* to his *Pourthiaea villosa* var. *typica*. *Pirus sinensis* var. *Maximowicziana* he does not mention. The latter species and *P. brunnea* are represented by fruiting specimens; *P. spectabilis* var. *albescens* is in bloom.

Photinia villosa var. **coreana** (Decne.) Rehder in Jour. Arnold Arb. II. 45 (1920).

Pirus mokpoensis Léveillé in Fedde, Rep. Spec. Nov. VII. 200 (1909).
Pourthiaea villosa var. *coreana* (Decne.) Nakai, Fl. Sylv. Kor. VI. 29 (1916).

KOREA: circa Mokpo, *U. Faurie*, no. 1556, May 1907 (holotype of *Pirus mokpoensis;* isotype in Herb. Arnold Arb.).

Pirus mokpoensis was first identified with *Photinia villosa* var. *coreana* by Nakai.

Photinia Beauverdiana Schneider in Bull. Herb. Boiss. sér. 2, VI. 319 (1906).

Photinia Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. IV. 334 (1907); Fl. Kouy-Tchéou, 349 (1915).—**Synon. nov.**

CHINA. Kweichou: Ly-po, *J. Cavalerie*, no. 2631, May 1899 (holotype of *P. Cavaleriei;* photo. in A. A.).

Photinia parvifolia Schneider, Ill. Handb. Laubholzk. I. 711, fig. 392 0–0′ (1906).

Photinia subumbellata Rehder & Wilson in Sargent, Pl. Wilson. I. 189 (1912).—**Synon. nov.**
Crataegus Cavaleriei Léveillé, Fl. Kouy-Tchéou, 346 (1915), quoad specimen cit. 1303; non Léveillé & Vaniot (1908).
Viburnum Komarovii Léveillé & Vaniot in Fedde, Rep. Spec. Nov. IX. 78 (1910); Fl. Kouy-Tchéou, 66 (1914).—**Synon. nov.**

CHINA. Kweichou: Pin-fa, montagne, *J. Cavalerie*, no. 1303, May 3, 1902 (? paratype of *Viburnum Komarovii;* photo. in A. A.); Ma-jo, *J. Cavalerie*, no. 1303, Oct. 1908 (holotype of *Viburnum Komarovii;* merotype in A. A.); no. 1892, Sept. 1903 (ex Léveillé, Fl. Kouy-Tchéou).

There seems to be considerable confusion in Léveillé's numbers. In Léveillé's herbarium in the cover of *Crataegus Cavaleriei* there is a flowering specimen from Pin-fa, May 3, 1902, with the original number 93 crossed out and 1303 written over it, but the fruiting specimen under no. 93 upon which Léveillé's description is based belongs to *Malus Sieboldii* (Rgl.) Rehd. As *Viburnum Komarovii* Léveillé describes (l. c.) under no. 1303 flowering and fruiting specimens, though he gives only October 1908 as collecting date under the original description, but in the Flore du Kouy-Tchéou he cites an additional number 1892, Sept. 1903, from Pin-fa which I have not seen. Apparently the flowering specimen in the cover of *Crataegus Cavaleriei* is the flowering specimen described, but not cited under *Viburnum Komarovii;* no reference to a specimen collected May 3, 1902 appears under *Crataegus Cavaleriei* or *Viburnum Komarovii*.

With the abundant material now at hand I cannot find that *P. subumbellata* Rehd. & Wils. is sufficiently distinct from *P. parvi-*

folia to be maintained as a species, since the extreme forms are connected by intermediate specimens which makes it difficult to separate clearly the two groups.

Photinia amphidoxa (Schneid.) Rehder & Wilson in Sargent, Pl. Wilson. I. 190 (1912).

Pirus Feddei Léveillé in Fedde, Rep. Spec. Nov. XII. 189 (1913); Fl. Kouy-Tchéou, 350 (1915).

CHINA. Kweichou: Pin-fa, *J. Cavalerie*, no. 2533, Oct. 11, 1905 (holotype of *Pirus Feddei;* photo. in A. A.).

Photinia crassifolia Léveillé, Fl. Kouy-Tchéou, 349 (1915), nomen seminudum.—Cardot in Bull Mus. Nat. Hist. Paris, XXV. 398 (1919).

Photinia Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. XI. 66 (1912); non Léveillé (1907).

Photinia crassifolia Levl. var. *denticulata* Cardot in Lecomte, Not. Syst. III. 372 (1918).

CHINA. Kweichou: Tin-fan, *J. Cavalerie*, no. 3571 (in part) June 1909 (holotype of *P. Cavaleriei;* merotype in A. A.); Gan-chouen, *J. Cavalerie*, no. 3571 (in part) April 1912 (paratype of *P. crassifolia;* merotype in A. A.).

This species was first published as *P. Cavaleriei* based on a specimen collected at Tin-fan in 1909 by Cavalerie and numbered 3571; in 1915 Léveillé enumerates under the name *P. crassifolia* the preceding specimen with the addition of a specimen from Gan-chouen collected in 1912 and also numbered 3571, but without reference to the previous name and description. The species varies in the pubescence of the inflorescence and in the denticulation of the leaves; in the specimen from Tin-fan the inflorescence is densely villous except the calyx, and the leaves are practically entire while in a flowering specimen from Gan-chouen the inflorescence is nearly glabrous, though the base of the peduncle and the branchlets are densely villous, and the leaves are entire, but are distinctly denticulate in a specimen from the same locality with an old densely villous inflorescence. The latter apparently is the specimen upon which Cardot based his var. *denticulata*, while the flowering specimen may be of the collection of 1910 also from Gan-chouen mentioned by him, but not referred to by Léveillé.

Photinia serrulata Lindley in Trans. Linn. Soc. XIII. 103 (1821), excl. syn. *Crataegus glabra* Thbg.

Stranvaesia Argyi Léveillé in Mem. Acad. Ci. Art. Barcelona, ser. 3, XII. 560 (Cat. Pl. Kiang-Sou, 20) (1916), pro synon. *S. Calleryanae* Dcne.

CHINA. Kiangsu: without locality, *Ch. d'Argy* [1848–66] (holotype of *Stranvaesia Argyi;* photo. in A. A.).

Stranvaesia Argyi seems to be only an herbarium name given by Léveillé to a specimen without any other data except Léveillé's label "*Stranvaesia Argyi* Lévl." He published it later erroneously as a synonym of *S. Calleryana*.

Photinia Bodinieri Léveillé in Fedde, Rep. Spec. Nov. IV. 334 (1907).—Cardot in Bull. Mus. Nat. Hist. Paris, XXV. 402 (1919).

Hiptage Esquirolii Léveillé in Fedde, Rep. Spec. Nov. X. 372 (1912); Fl. Kouy-Tchéou, 271 (1914).—**Synon. nov.**

Photinia serrulata Léveillé, Fl. Kouy-Tchéou, 349 (1915), quoad synon. et specimen cit. no. 2256.—Non Lindley.

CHINA. Kweichou: environs de Kouy-yang, mont. du Collège, *E. Bodinier*, no. 2256, May 18, 1898 (holotype of *Photinia Bodinieri;* photo. in A. A.); Choui-t'eou, route de Tin-fan à Lo-fou, alt. 900 m., *J. Esquirol*, no. 2097, May 4, 1900 (bel arbre, fleurs blanches; holotype of *Hiptage Esquirolii;* merotype in A. A.).

In his Flore du Kouy-Tchéou Léveillé refers his *Photinia Bodinieri* to *P. serrulata* Lindl., but as Cardot (l. c.) points out, *P. Bodinieri* can be readily distinguished by the larger flowers and the more connate styles.

Photinia Mairei Léveillé in Monde des Pl. ser. 2, XVIII. 28 (1916); Cat. Pl. Yun-Nan, 230 (1917).

CHINA. Yunnan: rochers, brousse des montagnes à Kiao-méti, 3100 m., *E. E. Maire*, May 1912 (holotype; merotype in A. A.).

Of this plant I have before me a rather meagre specimen with a small crowded paniculate inflorescence not leafy at base; the leaves are elliptic-obovate, crenate-serrulate and 6–7 cm. long. The inflorescence recalls that of *Eriobotrya*, but the nearly superior ovary removes it from that genus. I do not know any species either in *Eriobotrya* or in *Photinia* with which it could be compared.

Stranvaesia Davidiana Decaisne in Nouv. Arch. Mus. Paris, X. 179 (1874).

Pirus Cavaleriei Léveillé in Fedde Rep. Spec. Nov. XI. 66 (1912); Fl. Kouy-Tchéou, 350 (1915).—**Synon. nov.**

CHINA. Kweichou: Pin-fa, *J. Cavalerie*, no. 3569, Oct. 1908 (holotype of *Pirus Cavaleriei;* merotype in A. A.).

Eriobotrya Cavaleriei (Lévl.), comb. nov.

Hiptage Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. X. 372 (1912); Fl. Kouy-Tchéou, 271 (1914).

Eriobotrya Brackloi Hand.-Mazz. var. *atrichophylla* Handel-Mazzetti in Anz. Akad. Wiss. Wien Math. Naturw. Kl. 1922, no. 12, p. 103 (Pl. Nov. Sin. Forts. 16, p. 2) (1922).—**Synon. nov.**

CHINA. Kweichou: Pin-fa, montagne en pente, *J. Cavalerie*, no. 3220 May 20, 1907 (arbre de 9 m. de hauteur; fl. blanches odor; holotype of *Hiptage Cavaleriei;* merotype in A. A.).

In the original place of publication the citation of specimen and locality is lacking, but is given in Flore du Kouy-Tchéou (l. c.).

As *Eriobotrya Brackloi* var. *atrichophylla* Hand.-Mazz. becomes a synonym of *E. Cavaleriei* (Lévl.), typical *E. Brackloi* must be considered a variety of that species and should bear the name **Eriobotrya Cavaleriei** var. **Brackloi** (Hand.-Mazz.), new comb. (*E. Brackloi* Handel-Mazzetti in Anz. Akad. Wiss. Wien Math.-Naturw. Kl. 1922, no. 12, p. 102 [Pl. Nov. Sin. Forts. 16, p. 2] [1922]).

Eriobotrya Seguini (Lévl.) Cardot apud Guillaumin in Bull. Soc. Bot. France, LXXI. 287 (1924), "Seguinii."

Symplocos Seguini Léveillé in Fedde, Rep. Spec. Nov. x. 431 (1912); Fl. Kouy-Tchéou, 408 (1915).

Eriobotrya pseudo-Raphiolepis Cardot in Lecomte, Not. Syst. III. 371 (1918).

CHINA. Kweichou: environs de Ou-la-gay et de Hoang-ko-chou, *J. Seguin* in herb. *Bodinier*, nos. 2262, April 1898, and 2617, March 1, 1899 (syntypes of *Symplocos Seguini* [in herb. Edinb.] and of *Eriobotrya pseudo-Raphiolepis* [in herb. Paris]; photo. and fragments of no. 2617 [herb. Edinb.] in A. A.).

This species was first described by Léveillé as *Symplocos Seguini*, but the herbarium specimens bear the name *Lindera Seguini* Lévl. in his own handwriting. On duplicates of the same numbers in the Paris Herbarium Cardot based his *E. pseudo-Raphiolepis*. The connection was discovered when Guillaumin writing his paper "Observations sur les Symplocos d'Extrême-Orient" examined the type specimen of *Symplocos Seguini* and found that it was not a *Symplocos*, but an *Eriobotrya*.

Amelanchier asiatica (Sieb. & Zucc.) Endlicher apud Walpers, Rep. II. 55 (1843).—Nakai, Fl. Sylv. Kor. VI. 19, t. 1 (1916).

Pirus Taqueti Léveillé in Fedde, Rep. Sp. Nov. VII. 199 (1909).

Pirus Vanioti Léveillé, op. cit. 200 (1909).

KOREA: Hallaisan, in silvis, *U. Faurie*, nos. 1559, 1560 (ex Léveillé), 1561, May to July 1907 (syntypes of *Pirus Taqueti;* isotype of no. 1561 in A. A.); same locality, *E. Taquet*, no. 103, Oct. 1907 (syntype of *P. Taqueti*); Quelpaert, in silvis, *U. Faurie*, no. 1557, May 1907 (holotype of *Pirus Vanioti;* isotype in herb. A. A.).

Pirus Taqueti and *P. Vanioti* had already been identified with *Amelanchier asiatica* by Nakai (l. c.).

Malus Sieboldii (Reg.) Rehder in Sargent, Pl. Wilson. II. 293 (1915).

Crataegus Cavalerieï Léveillé & Vaniot in Bull. Soc. Bot. France, LV. 58 (1908); Fl. Kouy-Tchéou, 346 (1915), excl. no. cit. 1303.—**Synon. nov.**

Pirus subcrataegifolia Léveillé in Fedde, Rep. Spec. Nov. VII. 199 (1909).

Photinia rubro-lutea Léveillé in Fedde, Rep. Spec. Nov. IX. 460 (1911); Fl. Kouy-Tchéou, 349 (1915).—**Synon. nov.**

Crataegus Taquetii Léveillé in Fedde, Rep. Spec. Nov. X. 377 (1912).—**Synon. nov.**

Pirus Esquirolii Léveillé in Fedde, Rep. Spec. Nov. XII. 189 (1913); Fl. Kouy-Tchéou, 350 (1915).—**Synon. nov.**

Malus Toringo Siebold, Cat. Rais. I. 4 (1856), nomen.—*Nakai*, Fl. Sylv. Kor. VI. 35, t. 10 (1916).

KOREA. Quelpaert: Hallaisan, *U. Faurie*, no. 1558, June 1907 (holotype of *Pirus subcrataegifolia* and syntype of *Crataegus Taqueti*); in silvis Hallaisan, 900 m., *E. Taquet*, no. 2828, Oct. 1909 (syntype of *Crataegus Taqueti;* isotype in A. A.); in silvis Yengsil, 1000 m., *E. Taquet*, no. 4220, Aug. 12, 1910 (syntype of *Crataegus Taqueti;* isotype in A. A.).

CHINA. Kweichou: Pin-fa, montagne, *J. Cavalerie*, no. 93, July 23, 1902 (holotype of *Crataegus Cavalerieï;* photo. in A. A.); same locality, *J. Cavalerie*, no. 1304, April 2, 1902 (holotype of *Pirus Esquirolii;* photo. in A. A.); without locality, *J. Cavalerie*, no. 3303, Nov. 13, 1907 (holotype of *Photinia rubro-lutea;* merotype in A. A.).

Malus Sieboldii seems to be widely distributed in southeastern China, ranging west to Kweichou, as the following additional specimens in the herbarium of the Arnold Arboretum show: Chekiang (*N. T. Liou*, no. 442), Kiangsi (*H. H. Hu*, no. 943), Kwangtung (*Y. Tsiang*, no. 1381), Kwangsi (*R. C. Ching*, no. 5935), Hunan (*Handel-Mazzetti*, no. 11787, Pl. Sin. cur. Handel-Mazzetti, no. 94) and Kweichou (*Handel-Mazzetti*, no. 285, *Y. Tsiang*, nos. 5006 and 5521). The species does not seem to occur in northern China and its Chinese area shows no connection with the range of the species in Korea and Japan, but I can see no marked difference between the plants of the two areas and have to consider them conspecific in spite of their geographical separation.

Docynia Delavayi (Franch.) Schneider in Fedde, Rep. Spec. Nov. III. 180 (1906).

Cotoneaster Bodinieri Léveillé in Bull. Géog. Bot. XXV. 44 (1915); Cat. Pl. Yun-Nan, 229 (1917).—**Synon. nov.**

CHINA. Yunnan: près de la frontière de Kouy-Tchéou à Kiang-ti, *E. Bodinier*, April 9, 1897 (holotype of *Cotoneaster Bodinieri;* photo. and fragments in A. A.).

Cotoneaster Bodinieri was first identified with *D. Delavayi* by H. E. Evans according to a note on the type specimen.

Docynia rufifolia (Lévl.), comb. nov.

Pirus (*Cydonia*) *rufifolia* Léveillé in Bull. Géog. Bot. XXV. 46 (1915); Cat. Pl. Yun-Nan, 231 (1917), sphalmate "*rubifolia.*"

Malus docynioides Schneider in Bot. Gaz. LXIII. 400 (1917).—**Synon. nov.**

Docynia docynioides (Schneid.) Rehder in Jour. Arnold Arb. II. 58 (1920).

CHINA. Yunnan: flanc des coteaux arides à Lou-pou, 3050 m., *E. E Maire*, June 1912, "fleurs blanches; fruits jaunes, oblong" (type of *P. rufifolia;* merotype in A. A.).

Pyrus Calleryana Decaisne, Jard. Fruit. I. in textu ad t. 8 (1872).

Pirus Mairei Léveillé in Fedde, Rep. Spec. Nov. XII. 189 (1913); Cat. Pl. Yun-Nan, 231 (1917).

CHINA. Yunnan: Tche-hay, haies de la plaine, 2500 m., *E. E. Maire*, March 1911 (holotype of *Pirus Mairei;* merotype in A. A.).

Rosa multiflora Thbg. var. **adenophora** Franchet & Savatier, Enum. Pl. Jap. I. 134 (1875), nomen; II. 345 (1879).—Nakai, Fl. Sylv. Kor. VII. 30, t. 5 (1918).

Rosa Nakaiana Léveillé in Fedde, Rep. Spec. Nov. X. 432 (1912).

KOREA: "Corea media" *U. Faurie*, no. 330, July 1906 (holotype of *R. Nakaiana;* photo. in A. A.).

Rosa multiflora var. **quelpaertensis** (Lévl.) Rehder & Wilson in Sargent, Pl. Wilson. II. 335 (1915).

Rosa mokanensis Léveillé in Fedde, Rep. Spec. Nov. VII. 340 (1909), pro parte typica.—Willmott, Gen. Rosa, II. 511, t. (1914).

Rosa quelpaertensis Léveillé in Fedde, Rep. Spec. Nov. X. 378 (1912).

Rosa mokanensis var. *quelpaertensis* Willmott, Gen. Rosa, II. 512, t. (1914).

Rosa multiflora var. *microphylla* Nakai, Fl. Sylv. Kor. VII. 30 (1918), pro parte.—Non Franchet & Savatier.

KOREA. Quelpaert: Mokan, *E. Taquet*, no. 778, June 8, 1908 (in part; syntype of *R. mokanensis;* photo. and isotype in A. A.); in sepibus Hogno, *E. Taquet*, no. 2870, May 1909 (holotype of *R. quelpaertensis;* isotype in A. A.); in petrosis secus vias, *U. Faurie*, no. 1567, May 1907; in sepibus, *E. Taquet*, no. 5587, June 1911; Hoatien, *E. Taquet*, no. 5590, June 1911 (nos. 1567, 5587 and 5590 in herb. Léveillé sub *R. quelpaertensis*).

The type specimens of *R. mokanensis* consists of two branches, one representing *R. multiflora* and one *R. Wichuraiana;* the former must be considered the type of *R. mokanensis*, as the character "pedunculis glandulosis" applies only to this form.

Nakai refers *R. quelpaertensis* to *R. multiflora* var. *microphylla* Franch. & Savatier, but this variety is described as having ovate leaflets not cuneate at base, while in var. *quelpaertensis* the leaflets are generally obovate and cuneate.

Rosa multiflora var. **cathayensis** Rehder & Wilson in Sargent, Pl. Wilson. II. 304 (1915).

Rosa macrophylla var. *hypoleuca* Léveillé, Fl. Kouy-Tchéou, 354 (1915), nomen.

China. Kweichou: Gan-chouen, commune, *J. Cavalerie*, no. 3953, "fl. blanches" (holotype of *R. macrophylla* var. *hypoleuca;* photo. in A. A.). Yunnan: haies, plaine de Long-tou, alt. 2400 m., *E. E. Maire*, "fl. rosées" (as *R. clavigera* forma in herb. Léveillé; photo. in A. A.).

The flowers are white according to the collector and borne in few-flowered corymbs; the leaflets are rather small and densely grayish pubescent beneath, but not whitish as the name seems to imply. Another specimen collected by Bodinier in 1888 on the "Pehoō chan" and named *R. macrophylla* var. *hypoleuca* in Léveillé's herbarium but not in his handwriting belongs to *R. Sweginzowii* Koehne or a related species.

Rosa multiflora var. **carnea** Thory in Redouté, Roses, II. 67, t. (1821).—Rehder & Wilson in Sargent, Pl. Wilson. II. 305 (1915).—Byhouwer in Jour. Arnold Arb. X. 86 (1929).

Rosa Lebrunei Léveillé in Bull. Géog. Bot. XXV. 46 (1915); Cat. Pl. Yun-Nan, 235 (1917).

Rosa Blinii Léveillé, l. c. (1915); l. c. 234 (1917).

China. Yunnan: haies, plaine de La-kou, alt. 2400 m., *E. E. Maire*, May [1910–14], "épineux, buissonant, haut 0.80 m.; fl. doubles, roses ou rouges, inodores" (holotype of *R. Lebrunei;* photo. in A. A.); haies de la plaine à Tong-tchouan, alt. 2500 m., *E. E. Maire;* Mai 1910–14 "petit rosier, épineux, fl. rouges, abondantes par bouquets" (type of *R. Blinii;* photo. in A. A.)

Rosa Wichuraiana Crépin in Bull. Soc. Bot. Belg. XXV. 189 (1886).—Rehder & Wilson in Sargent, Pl. Wilson. II. 335 (1915).

Rosa Luciae Franchet & Rochebrune apud Crépin in Bull. Soc. Bot. Belg. X. 323 (1871), pro parte.—Nakai, Fl. Sylv. Kor. VII. 28, t. 2 (1918), pro parte.

Rosa Taqueti Léveillé in Fedde, Rep. Spec. Nov. VII. 199 (1909), pro parte typica.

Rosa mokanensis Léveillé in Fedde, Rep. Spec. Nov. VII. 340 (1909), pro parte.

Rosa acicularis var. *Taquetii* Nakai in Tokyo Bot. Mag. XXX. 241 (1916) et Fl. Sylv. Kor. VII. 38 (1918), tantum quoad synon. citatum.

Korea. Quelpaert: Hallaisan, *E. Taquet*, no. 102, October 1907 (in part, as to fruiting specimen; syntype of *R. Taqueti;* photo. in A. A.); Mokan, *E. Taquet*, no. 778, June 8, 1908 (in part; syntype of *R. mokanensis;* photo. in A. A.); Moktjafang [?], *E. Taquet*, no. 5586, Aug. 25, 1911 (as *R. Mokanensis* in herb. Léveillé); in sepibus, *E. Taquet*, nos. 5588, 5589, May 1911 (as *R. Fauriei* Lévl. in herb. Léveillé).

The type specimen of *R. Taqueti* consists of two branches, one belonging to *R. Wichuraiana* and one to *R. acicularis;* according to the description "stipulae . . . margine glanduloso-fimbriatae; inflorescentia spicata flexuosa; fructus rubri, globosi, ut pedicelli glandulosi; styli hirti, columnares" the branch of *R. Wichuraiana* should be considered the type. The type specimen of *R. mokanensis* also consists of two branches, of which, as shown under *R. multiflora* var. *quelpaertensis*, that representing var. *quelpaertensis* must be considered the type; the other specimen is an unusually small-leaved form of *R. Wichuraiana*. Taquet's nos. 5588 and 5589 are named *R. Fauriei* Lévl. in Léveillé's handwriting, but the type of that species belongs to *R. Maximowicziana* Reg. and the paratype to *R. acicularis* Lindl.

Nakai refers *R. Wichuraiana* as a synonym to *R. Luciae* Franch. & Rochebr., which, though very closely related, may be distinguished by its more upright habit, thinner and narrower, usually acute, mostly 7 leaflets and smaller flowers.

Rosa Maximowicziana Regel in Act. Hort. Petrop. v. 295, 378 (1878).—Nakai, Fl. Sylv. Kor. VII. 26, t. 1 (1918).

Rosa Fauriei Léveillé in Fedde, Rep. Spec. Nov. VII. 199 (1909), excl. specimine Faurie, no. 99.

KOREA: Ouen-san, *U. Faurie*, no. 328, July 1906 (syntype of *R. Fauriei;* photo. in A. A.).

The description of *R. Fauriei* is based almost exclusively on Faurie's no. 328 which is the first specimen enumerated, and constitutes the type of species; from the second specimen, Faurie's no. 99, only the description of the fruit was drawn and this specimen belongs to *R. acicularis* Lindl. The name *R. Fauriei* does not appear on Faurie's no. 328 in the herbarium of Léveillé.

Rosa Brunonii Lindley, Ros. Monog. 120, t. 14 (1820).—Byhouwer in Jour. Arnold Arb. x. 87 (1929).

Rosa clavigera Léveillé in Fedde, Rep. Spec. Nov. XIII. 338 (1914); Cat. Pl. Yun-Nan, 234 (1917).

CHINA. Yunnan: haies, plaine de Long-tan, alt. 2500 m., *E. E. Maire*, May [1910–14] "grand rosier; feuilles vert luisant, pubescentes au dessous; fl. blanches" (holotype of R. clavigera; photo. in A. A.).

Rosa Rubus Léveillé & Vaniot in Bull. Soc. Bot. France, LV. 55 (1908).—Willmott, Gen. Rosa, II. 507 (1914).—Léveillé, Fl. Kouy-Tchéou, 354 (1915).—Byhouwer in Jour. Arnold Arb. x. 90 (1929).

Rosa Rubus var. *yunnanensis* Léveillé in Bull. Soc. Bot. France, LV. 55 (1908); Cat. Pl. Yun-Nan, 235 (1917).

China. Kweichou: route de Pin-yang, *L. Martin* in herb. Bodinier, no. 2603, May 12, 1899, (holotype of *R. Rubus;* photo. in A. A.). Yunnan: montagnes, an bord de la plaine de Lo-pin-tchéou, *E. Bodinier*, no. 2603,[1] April 6, 1897, "branches sarmentenses" (holotype of *R. Rubus* var. *yunnanensis;* photo. and merotype in A. A.).

The original labels in Léveillé's herbarium of *R. Rubus* and *R. Rubus* var. *yunnanensis* seem to have been interchanged; they do not bear Léveillé's names which are on separate slips in Léveillé's handwriting, but the name *R. Rubus* var. *yunnanensis* does not appear at all on the specimen; instead a slip with the the name *R. Bodinieri*, a species identical with *R. microcarpa* Lindl., has been pasted by mistake on that sheet. The specimen with the label of Bodinier's no. 2603 agrees with the description of var. *yunnanensis* in the characters "petala apice rotundata; folia utrinque viridia, argute dentata," while the sheet with Bodinier's label of the Yunnan specimen contains the plant which has crenate-serrate leaflets grayish beneath and emarginate petals, all characters given by Léveillé for typical *R. Rubus*. To the Arnold Arboretum Léveillé had sent in 1915 as *R. Rubus* a specimen which agrees with *R. Rubus yunnanensis;* this shows that even at that time confusion existed or that Léveillé having more material of var. *yunnanensis* sent a specimen of the variety instead of the type.

Rosa Gentiliana Léveillé & Vaniot in Bull. Soc. Bot. France, LV. 55 (1908).—Willmott, Gen. Rosa, II. 513, t. (1914).—Rehder & Wilson in Sargent, Pl. Wilson. II. 312 (1915).—Léveillé in Mem. Acad. Ci. Art. Barcelona, ser. 3, XII. no. 22, p. 20 (Cat. Pl. Kiang-Sou); Cat. Ill. Seu-Tchouen, 164, t. 59 (1918).

China. Kiangsu: without precise locality, *Ch. d'Argy* [1846–66]; (holotype; fragments in A. A.).

The two illustrations cited above are obviously based on the same specimen which apparently is the type, but does not seem to be in Léveillé's herbarium now.

I have seen no material of this species except some fragments sent by Léveillé in 1915 to the Arnold Arboretum.[2] The species is widely distributed in eastern and Central China, but the peculiar shape of the leaflets stressed by Léveillé represents apparently an aberrant form not constant for the species.

[1] This number in pencil in Léveillé's, not in Bodinier's, handwriting.

[2] The type specimen of this species, of *R. Rubus*, *R. adenoclada* and possibly of some other species are not now in the Herbarium Léveillé; they were loaned to Miss Willmott when she was preparing her work The Genus Rosa and probably became separated from Léveillé's collection.

Rosa adenoclada Léveillé in Fedde, Rep. Spec. Nov. x. 431 (1912); Fl. Kouy-Tchéou, 353 (1915).—Willmott, Gen. Rosa, II. 517, t. (1914).

Rosa Gentiliana Rehder & Wilson in Sargent, Pl. Wilson. II. 312 (1915) quoad syn. *R. adenoclada*.—Non Léveillé.

Rosa Gentiliana var. *adenoclada* Léveillé, Cat. Pl. Yun-Nan, 234 (1917), nomen.

CHINA. Kweichou: Grotte de Gai-kio, *J. Esquirol*, no. 2100, May 3, 1910 "couleur rouge" (holotype).

The material of this species in Léveillé's herbarium is very meagre consisting of a single leaf, a piece of a leafless branch and some detached flowers and leaflets, but there is a good figure of a flowering branch in Miss Willmott's book. It is a very puzzling Rose and apparently does not belong to *R. Gentiliana* where it was placed by my former colleague, Mr. Wilson, and myself. It differs from that species in the pilose, more or less free styles, in the red color of the flowers and in the slightly bristly and stipitate-glandular branch. It may possibly be a hybrid of *R. Rubus* Lévl. and *R. chinensis* which would account for the color of the flowers and the character of the styles. It is also somewhat similar to *R. lucidissima* Lévl.

Rosa longicuspis A. Bertoloni in Mem. Accad. Sci. Bologna, XI. 201, t. 13 (Misc. Bot. XXI. 15, t. 3) (1861).—Rehder & Wilson in Sargent, Pl. Wilson. II. 313 (1915).—Byhouwer in Jour. Arnold Arb. XI. 88 (1929).—Léveillé, Cat. Pl. Yun-Nan, 235 (1917).

Rosa Willmottiana Léveillé in Fedde, Rep. Spec. Nov. XI. 299 (1912).—Willmott, Gen. Rosa, 521, t. (1914).

Rosa Charbonneaui Léveillé in Fedde, Rep. Spec. Nov. XIII. 338 (1914).

CHINA. Yunnan: brousse et haies a Long-ky, 700 m., *E. E. Maire*, June 1911, "Eglantier épineux a long rameaux; fl. blanches" (holotype of *R. Willmottiana;* photo. in A. A.); plaine de Long-tan, 2500 m., *E. E. Maire*, May 1913 "rosier épineux à long rameaux; fl. d'abord blanches, puis sanguines" (holotype of *R. Charbonneaui;* photo. in A. A.).

Rosa Willmottiana represents a form with rather large leaflets up to 8.5 cm. long and not reticulate beneath, while *R. Charbonneaui* has much smaller more finely serrate leaflets reticulate beneath.

Rosa microcarpa Lindley, Ros. Monog. 130, t. 18 (1820).—Rehder & Wilson in Sargent, Pl. Wilson. II. 314 (1915).

Rosa sorbiflora Focke in Gard. Chron. ser. 3, XXXVII. 227, fig. 96 (1905).—Léveillé, Fl. Kouy-Tchéou, 354 (1915).

Rosa Chaffanjoni Léveillé & Vaniot in Bull. Soc. Bot. France, LV. 56 (1908).

Rosa Bodinieri Léveillé & Vaniot, l. c. (1908).—Willmott, Gen. Rosa, II, 485, t. (1914).—Léveillé, Fl. Kouy-Tchéou, 353 (1914).

Rosa Esquirolii Léveillé & Vaniot in Bull. Soc. Bot. France, LV. 56 (1908).—Willmott, Gen. Rosa, II. 485, t. (1914).—Léveillé, Fl. Kouy-Tchéou, 353 (1915).

Rosa Cavaleriei Léveillé in Fedde, Rep. Spec. Nov VIII. 61 (1910).

CHINA. Kweichou: environs de Kouy-yang, mont du Collège, haies, près des villages, *J. Chaffonjon* in herb. Bodinier, no. 2292, June 2, 1898, "tiges sans épines; fl. blanches" (holotype of *R. Chaffanjoni;* photo. and merotype in A. A.); mont de Loutsong-koan, cc. dans la montagne, E. Bodinier, no. 1604, May 31, 1897, "fleurs blanches" (holotype of *R. Bodinieri;* photo. and merotype in A. A.); murs de Tchen-lin, *J. Cavalerie*, no. 117, June 1904, "fl. blanches" (holotype of *R. Esquirolii;* photo. in A. A.); montagnes Hoang-tsao-pa, *J. Esquirol*, no. 1517, June 1909, "fl. blanches" (holotype of *R. Cavaleriei;* photo. and merotype in A. A.).

Rosa Chaffanjoni is a form with unarmed branches; the styles described as glabrous by Léveillé are villous except near the base. *R. Esquirolii* represents a form with very small leaflets.

Rosa Banksiae Aiton, Hort. Kew. ed. 2, III. 258 (1811).—Byhouwer in Jour. Arnold Arb. XI. 91 (1929).

Rosa Banksiae f. *aculeata* Léveillé, Cat. Pl. Yun-Nan, 234 (1917), nomen.

Rosa Banksiae f. *subinermis* Léveillé, l. c. (1917), nomen.

Rosa Banksiae f. *albiflora* Léveillé, l. c. (1917), nomen.

CHINA. Kweichou: Kouy-yang, mont. du Collège, dans les haies, près des villages, *J. Chaffanjon* in herb. Bodinier, no. 2259, May 15, 1898 "fl. blanches, souvent doubles"; Gan-chouen, *J. Cavalerie*, no. 3943, May 1910. Yunnan: Tong-tchouan, haies de la plaine, alt. 2500, *E. E. Maire*, April [1910–14], "fl. blanches doubles"; environs de Yun-nan-sen, *E. Bodinier*, March 24, 1897, "fl. tantôt simples, blanches, très souvent doubles."

There are no specimens in the Léveillé herbarium named f. *aculeata* and f. *subinermis;* these names were apparently taken from Focke's f. *subinermis fl. pleno* and f. *aculeata fl. pleno albo* (in Not. Bot. Gard. Edinb. v. 65, 66 [1913]). Also of *f. albiflora* there is no specimen and this name may belong either here or to the white, single-flowered *R. Banksiae* f. *normalis* Regel.

Rosa Banksiae f. **lutea** Lindl. Bot. Reg. XIII. t. 1105 (1827).—Byhouwer in Jour. Arnold Arb. XI. 92 (1929).

Rosa Banksiae f. *luteiflora* Léveillé, cat. Pl. Yun-Nan, 234 (1917), nomen.

CHINA. Yunnan: haies de la plaine à Tong-tchouan, alt. 2500 m., *E. E. Maire*, April [1910–14], "fl. jaunes, doubles, odorantes."

There is no specimen labeled f. *luteiflora* in Léveillé's herbarium, but the name doubtless belongs to the yellow double flowered form which is represented in his herbarium.

Rosa lucidissima Léveillé in Fedde, Rep. Spec. Nov. IX. 444 (1911); Fl. Kouy-Tchéou, 354 (1915).—Willmott, Gen. Rosa, II. 519, t. (1914).—Rehder & Wilson in Sargent, Pl. Wilson. II. 320 (1915), sub *R. chinensis* f. *spontanea*.

CHINA. Kweichou: Pin-fa, précipices, *J. Cavalerie*, no. 990, April 13, 1903, "fl. rouges, odorantes" (holotype; photo. in A. A.); Gan-chouen, Hin-y-fou, *J. Cavalerie*, nos. 3927, 3942, June 1912.

This peculiar Rose belongs apparently near *R. laevigata*, but differs in the less prickly and bristly branchlets and peduncles, in the adnate stipules and the red flowers; it probably is a hybrid of this species and of *R. chinensis* from which it is easily distinguished by the 3-foliolate leaves and the bristly receptacle, pedicels and branchlets. Cavalerie's nos. 3927, 3942 designated by Léveillé in his herbarium as *R. lucidissima* var. lack the bristles and represent obviously a form approaching *R. chinensis*, but differing in the 3-foliolate leaves with more coriaceous leaflets. *Rosa lucidissima* is very similar to × *R. anemonoides* Rehd. (in Jour. Arnold Arb. III. 13. 1921), supposed to be a hybrid between *R. laevigata* and *R. odorata;* it differs from *R. lucidissima* chiefly in the larger pink flowers and in the stipules being adnate only about one half their length.

Rosa odorata Sweet, Hort. Suburb. Lond. 119 (1818).—Rehder & Wilson in Sargent, Pl. Wilson. II. 338 (1915).—Léveillé, Cat. Pl. Yun-Nan, 235 (1917)—Byhouwer in Jour. Arnold Arb. XI. 98 (1929).

Rosa gechouitangensis Léveillé in Fedde, Rep. Spec. Nov. XI. 299 (1912).
Rosa oulengensis [*sic*] Léveillé, l. c. (1912).—Willmott, Gen. Rosa, II. 523, t. (1914).
Rosa tongtchouanensis Léveillé in Fedde, Rep. Spec. Nov. XI. 300 (1912).—Willmott, Gen. Rosa, II. 523, t. (1914).

CHINA. Yunnan: Ge-choui-tang, à flancs des coteaux calcaires, 2450 m., *E. E. Maire*, April 1911, "Rose thé semidouble, à long rameaux" (holotype of *R. gechouitangensis;* photo. in A. A.); Ou-long, haies des tertres, 2500 m., *E. E. Maire*, April 1911, "petit rosier épineux; fl. roses" (holotype of *R. oulengensis;* photo. in A. A.); haies de Tong-tchouan, alt. 2500 m., *E. E. Maire*, April 1911, "rosier de Bengale; fl. roses" (syntype of *R. tongtchouanensis*); haies de La-kou, alt. 2400 m., *E. E. Maire*, March 1911 "rosier épineux, à long rameaux; fl. blanches doubles, inodores" (syntype of *R. tongtchouanensis;* photo. in A. A.).

The three species of Léveillé's cited above are all double-flowered forms of *R. odorata* and therefore must be either cultivated or escaped from cultivation.

Rosa odorata var. **gigantea** (Collet) Rehder & Wilson in Sargent, Pl. Wilson. II. 338 (1915).—Léveillé, Cat. Pl. Yun-Nan, 235 (1917).—Byhouwer in Jour. Arnold Arb. XI. 94 (1929).

Rosa Duclouxii Léveillé in herb. ex Rehder & Wilson in Sargent, Pl. Wilson. II. 339 (1915) et ex Léveillé, Cat. Pl. Yun-Nan, 235 (1917), pro synon. *R. odoratae* var. *giganteae*.

CHINA. Yunnan: environs de Yun-nan-sen, dans la mont., bord des ruisseaux, *F. Ducloux*, March 28, 1897, "grande liane sarmenteuse; gr. fl. blanches" (holotype of *R. Duclouxii;* photo. in A. A.).

Rosa acicularis Lindley, Monog. 44, t. 8 (1920).

Rosa acicularis var. *Gmelini* (Bge.) C. A. Meyer, in Mém. Acad. Sci. St. Pétersb. sér. 6, VI. 17 (Ueber Zimmtros.) (1847).—Nakai in Tokyo Bot. Mag. XXX. 241 (1916); Fl. Sylv. Kor. VII. 37, t. 10 (1918).

Rosa Fauriei Léveillé in Fedde, Rep. Spec. Nov. VII. 199 (1909), quoad Faurie, no. 99.

Rosa Taqueti Léveillé in Fedde, Rep. Spec. Nov. VII. 199 (1909), pro parte, quoad specimen fructibus carens.

Rosa Korsakoviensis Léveillé in Fedde, Rep. Spec. Nov. X. 378 (1912).—Willmott, Gen. Rosa, II. 517, t. (1914).

Rosa acicularis var. *Taquetii* Nakai in Tokyo Bot. Mag. XXX. 241 (1916) et Fl. Sylv. Kor. VII. 38, t. 11 (1918) pro parte, synon. citato exclud.

KOREA: secus vias regionis interioris, *U. Faurie*, no. 99, Sept. 4, 1901 (syntype of *R. Fauriei;* photo. in A. A.); Hallaisan, *E. Taquet* no. 102, Oct. 1907 (in part, as to branch without fruit; syntype of *R. Taqueti;* photo. in A. A.); in sepibus Hallaisan, 1700 m., *E. Taquet*, no. 774, Sept. 7, 1908, et Hallaisan, 1700 m., sed in horto missionis plantata, *E. Taquet*, no. 4228 May 10, 1910 (both as *R. Taqueti* in herb. Léveillé). Saghalin: circa Korsakof, *U. Faurie*, no. 570, Aug. 1908 (holotype of *R. Korsakoviensis*).

The type of *R. Fauriei* is Faurie's no. 328 which represents *R. Mazimowicziana* Reg. The type of *Rosa Taqueti* is identical with *R. Wichuraiana;* the type specimen, Taquet's no. 102, consists of three branches, one with fruits on which apparently the description is based (see under *R. Wichuraiana* p. 312) and which represents *R. Wichuraiana* and two sterile specimens which belong to *R. acicularis;* the only part of the description which is clearly applicable to the two latter specimens is "caules niger et lucidus," the rest applies to *R. Wichuraiana* or both. Besides the type there are two other specimens, Taquet's no. 774 and 4228 labeled *R. Taqueti* in Léveillé's handwriting which both belong to *R. acicularis*, but are not cited with the original description. Apparently Léveillé later became confused as to the real identity of his *R. Taqueti* and applied the name to the wrong species. The same mistake was made by Nakai and therefore his name though meant for a form of *R. acicularis*, becomes technically according to the name-bringing

synonym, a synonym of *R. Wichuraiana*. The form distinguished as var. *Taquetii* by Nakai represents a form devoid of bristles.

Rosa Marretii Léveillé in Fedde, Rep. Spec. Nov. VIII. 281 (1910).—Willmott, Gen. Rosa, II. 495, t. (1914).—Nakai in Tokyo Bot. Mag. XXXVI. 63 (1922).

Rosa rubrostipullata Nakai in Tokyo Bot. Mag. XXX. 242 (1916); Fl. Sylv. Kor. VII. 40, t. 13 (1918).

SAGHALIN: circa Korsakof, *U. Faurie*, no. 571, Sept. 10, 1908 (holotype of *R. Marretii;* isotype in A. A.), no. 572, Aug. 1908 (as *R. Marretii* in herb. Léveillé; as *R. sp.* in A. A.).

Faurie's no. 572 not cited with the original description is in bloom; it has like the specimen of no. 571 in the herbarium of the Arnold Arboretum slightly broader leaflets and lacks the peculiar ascending prickles at the base of the branchlets present in the type specimen. *Rosa Marretii* differs from *R. davurica* Pall. chiefly in the green, glabrous or glabrescent and not glandular under side of the leaflets and in the ascending, not recurved prickles.

Rosa Davidi Crép. var. **elongata** Rehder & Wilson in Sargent, Pl. Wilson. II. 323 (1915).—Byhouwer in Jour. Arnold Arb. X. 99 (1929).

Rosa Parmentieri Léveillé in Fedde, Rep. Spec. Nov. XIII. 339 (1914); Cat. Pl. Yun-Nan, 235 (1917).

CHINA. Yunnan: brousse de Io-chan, 3400 m., *E. E. Maire*, June 1913, "rosier épineux, buissonant; fl. blanches" (holotype of *R. Parmentieri;* photo. in A. A.).

Rosa sertata Rolfe in Bot. Mag. CXXXIX. t. 8473 (1913).—Byhouwer in Jour. Arnold Arb. X. 100 (1929).

Rosa iochanensis Léveillé in Fedde, Rep. Spec. Nov. XIII. 339 (1914); Cat. Pl. Yun-Nan, 234 (1917).

CHINA. Yunnan: Mont Io-chan, alt. 3300 m., *E. E. Maire*, June 1913 "rosier à rameaux fins, épineux, buissonant, haut 0.80 m.; fl. rouges" (holotype of *R. iochanensis;* photo. in A. A.).

Rosa omeiensis Rolfe in Bot. Mag. CXXXVIII. t. 8471 (1912).—Rehder & Wilson in Sargent, Pl. Wilson. II. 331 (1915)—Léveillé, Cat. Pl. Yun-Nan, 235 (1917).—Byhouwer in Jour. Arnold Arb. X. 102 (1929).

Rosa Sorbus Léveillé in Fedde, Rep. Spec. Nov. XIII. 338 (1914).
Rosa sericea f. *aculeata* Focke apud Léveillé, Cat. Pl. Yun-Nan, 235 (1917), nomen.
Rosa sericea f. *eglandulosa* Léveillé, l. c. (1917), nomen.
Rosa sericea f. *inermis* Léveillé, l. c. (1917), nomen.

CHINA. Yunnan: brousse à mi-mont du Io-chan, alt. 3300 m., *E. E. Maire*, June 1913, "grand rosier épineux buissonant, 2 m.; fl. blanches," (holotype of *R. Sorbus;* photo. in A. A.).

Rosa Mairei Léveillé in Fedde, Rep. Spec. Nov. XI. 299 (1912); Cat. Pl. Yun-Nan, 235 (1917).—Willmott, Gen. Rosa, II. 521 (1914).—Rehder & Wilson in Sargent, Pl Wilson. II. 343 (1915).—Byhouwer in Jour. Arnold Arb. X. 103 (1929).

CHINA. Yunnan: collines arides autour de Tong-chouan, 2600 m., *E. E. Maire*, April 1911, "rosier buissonant, à fortes épines triangulaires; fl. blanches" (holotype; photo. in A. A.).

Prunus Persica (L.) Batsch, Beytr. Entwick. Gesch. Naturr. 30 (1801).—Léveillé in Mem. Acad. Ci. Art. Barcelona, ser. 3, XII. 560 (Cat. Pl. Kiang-Sou, 20) (1916).

Prunus Persica var. *lasiocalyx* Léveillé & Vaniot in Bull. Bot. Soc. France, LV. 58 (1908); in Mem. Acad. Ci. Art. Barcelona, ser. 3, XII. 560 (Cat. Pl. Kiang-Sou, 20) (1916).

Prunus daemonifuga Léveillé & Vaniot in Bull. Bot. Soc. France, LV. 58 (1908).

CHINA. Kiangsu: Song-kiang-fan, *Ch. d'Argy* (5 specimens, syntypes of *P. Persica* var. *lasiocalyx;* photo. in A. A.); Tao-chow; Tao-tze-chow, *Ch. d'Argy* (holotype of *P. daemonifuga;* photo. in A. A.).

Prunus persica var. *lasiocalyx* seems scarcely different from the type and *P. daemonifuga* was reduced to synonymy by Léveillé himself in 1916 (l. c.).

Prunus Persica var. **longistyla** Léveillé in Bull. Bot. Soc. France, LV. 58 (1908); in Mem. Acad. Ci. Art. Barcelona, ser. 3, 560 (Cat. Pl. Kiang-Sou, 20) (1916).

CHINA. Kiangsu: without locality, *Ch. d'Argy ?* (holotype; photo. in A. A.).

On account of its long style this variety resembles *P. kansuensis* Rehd. which differs, however, in its slenderer branches, glabrous winter-buds, less pubescent sepals glabrous inside, white or nearly white, rather smaller flowers and is only known as a wild plant from the Kansu-Tibetan frontier at altitudes of 6000–8000 ft.; it also differs markedly from *P. Persica* in its stone not being pitted. Léveillé's variety is apparently a form of the cultivated Peach, though the length of the style is an unusual character in this species.

Prunus japonica var. **Nakaii** (Lévl.) Rehder in Jour. Arnold Arb. III. 29 (1921).

Prunus Nakaii Léveillé in Fedde, Rep. Spec. Nov. VII. 198 (1909), "*P. Nakai*".—Koehne in Sargent, Pl. Wilson. I. 267 (1912).—Nakai, Fl. Sylv. Kor. v. 36, t. 22 (1916).

KOREA: Ouen-san, in lacunis montium, *U. Faurie*, no. 334, July 1906 (holotype of *P. Nakai;* isotype in A. A.).

Prunus discadenia Koehne in Sargent, Pl. Wilson. I. 200 (1912).

Prunus myrtacea Léveillé in Bull. Géog. Bot. XXV. 45 (1915); Cat. Pl. Yun-Nan, 234 (1917).

CHINA. Yunnan: brousse des montagnes à Pe-long-tsin, 3200 m., *E. E. Maire*, June 1912 (holotype of *P. myrtacea;* photo. in A. A.).

Prunus odontocalyx Léveillé in Bull. Géog. Bot. XXV. 45 (1915); Cat. Pl. Yun-Nan, 234 (1917).

CHINA. Yunnan: haut plateau de Ta-hai-tse, 3200 m., *E. E. Maire*, May 1912 (holotype; merotype in A. A.).

This species I have not been able to identify with any previously described *Prunus*. It apparently belongs in Koehne's Series Oxyodonta of his subsection Ceraseidos, but differs from the species known to me in its longer and narrower leaves (not yet fully unfolded) quite glabrous except a fugaceous silky pubescence along the midrib and in the 2–3-flowered racemes on a short peduncle 3–5 mm. long with narrow oblong-lanceolate caducous bracts to 1 cm. long.

Prunus Padus Linnaeus, Spec. Pl 473 (1753).—Nakai, Fl. Sylv. Kor. v. 18, t. 3 (1916).

Prunus Fauriei Léveillé in Fedde, Rep. Spec. Nov. VII. 198 (1909).

KOREA. Quelpaert: Hallaisan, 1500 m., *U. Faurie*, no. 1549, June 17, 1907, "rara, e basi ramosa, 2 m., alta 5–6 m. lata" (holotype of *P. Fauriei;* photo. in A. A.).

Nakai (op. cit. 15) cites *P. Fauriei* as a synonym under *P. Buergeri* Miq. (= P. Buergeriana Miq.), but under *P. Padus* he cites "*P. Fauriei* Lévl. in litt. fide Taquet." Koehne (in Fedde, Rep. Spec. Nov. XII. 135. 1913) states that *P. Fauriei* hardly differs from *P. Padus*, to which I agree with the original specimen from the Herbarium Léveillé before me.

Prunus Padus L. var. **seoulensis** (Lévl.) Nakai, Fl. Sylv. Kor. v. 19 (1916).

Prunus seoulensis Léveillé in Fedde, Rep. Spec. Nov. VII. 198 (1909).

KOREA: Namsan Seoul, *U. Faurie*, no. 331, July 1906 (holotype of *P. seoulensis;* isotype in A. A.).

Koehne (in Fedde, Rep. Spec. Nov. XII. 134. 1913) states that *P. seoulensis* hardly differs from typical *P. Padus* and that it possibly belongs to var. *commutata* Dipp.

Prunus pubigera (Schneid.) Koehne in Sargent, Pl. Wilson. I. 67 (1911).

Prunus (Padus) *Vanioti* Léveillé in Bull. Géog. Bot. XXV. 45 (1915); Cat. Pl. Yun-Nan, 234 (1917).

CHINA. Yunnan: flanc aride des montagnes à Ma-kong, 2700 m., *E. E. Maire*, April 1912 (holotype of *P. Vanioti;* merotype in A. A.).

Prunus Maackii Rupr. var. **diamantina** (Lévl.) Koehne in Fedde, Rep. Spec. Nov. XII. 134 (1913).

Prunus diamantina Léveillé in Fedde, Rep. Spec. Nov. VII. 198 (1909). KOREA: in Monte des Diamants, *U. Faurie*, no. 332 (holotype of *P. diamantina*).

Nakai (Fl. Sylv. Kor. v. 17. 1916) refers *P. diamantina* to *P. Maackii* as a synonym without recognizing it as a variety.

LEGUMINOSAE

Albizzia kalkora (Roxb.) Prain in Jour. As. Soc. Bengal, LXVI. 511 (1897).

Albizzia Esquirolii Léveillé, Fl. Kouy-Tchéou, 224 (1914).—**Synon. nov.** CHINA. Kweichou: Tou-chan, *J. Cavalerie* in herb. Bodinier, no. 2634, June 1899 (ex Léveillé; syntype of *A. Esquirolii*); same locality, *J. Esquirol*, no. 431, June 1905 (syntype of *A. Esquirolii;* merotype in A. A.).

Acacia Delavayi Franchet, Pl. Delavay. 194 (1890).

Acacia Cavaleriei Léveillé, Fl. Kouy-Tchéou, 222 (1914), nomen.—**Synon. nov.**

CHINA. Kweichou: Mou-you-se, *J. Cavalerie*, no. 2041, June 1904 "tige lianeuse court sur les murs" (holotype of *A. Cavaleriei;* photo. in A. A.).

I have not seen the type of *A. Delavayi*, but Cavalerie's specimen which is in bloom seems to agree well with Delavay's description except that the only leaf present has 6 pairs of pinnae and the leaflets are up to 1 cm. long; Franchet describes also the fruit, but Cavalerie's specimen has only flower-heads mostly in bud.

The original description of *Acacia Cavaleriei* I have not been able to locate; possibly Léveillé did not publish a description.

Bauhinia touranensis Gagnepain in Lecomte, Not. Syst. II. 181 (March 25, 1912); in Lecomte, Fl. Gén. Indo-Chine, II. 134, fig 14, 8–13 (1913).—Léveillé, Fl. Kouy-Tchéou, 227 (1914).

Bauhinia Rocheri Léveillé in Fedde, Rep. Spec. Nov. XI. 31 (July 1, 1912). CHINA. Kweichou: forêt de Siang-chou, alt. 800 m., *J. Esquirol*, no. 2131, May 20, 1910 (holotype of *B. Rocheri;* photo. in A. A.); Houakiang, *J. Cavalerie*, no. 2128, June 1904 (ex Léveillé, Fl. Kouy-Tchéou).

Bauhinia Rocheri was referred to *B. touranensis* as a synonym by Gagnepain in 1913 (l. c.).

Bauhinia densiflora Franchet, Pl. Delavay. 191 (1890).—Léveillé, Fl Kouy-Tchéou, 227 (1914).

Bauhinia Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. XI. 31 (1912). CHINA. Kweichou: Lo-fou, *J. Cavalerie*, no. 3676, Aug. and Oct. 1908, 1909 (holotype; photo. in A. A.); Pin-fa, *J. Cavalerie*

no. 659; descente du fleuve, *J. Esquirol*, nos. 507, 890 (ex Léveillé, Fl. Kouy-Tchéou).

Bauhinia Cavaleriei was referred by Léveillé as a synonym to *B. densiflora* in his Flore du Kouy-Tchéou.

Bauhinia yunnanensis Franchet, Pl. Delavay. 190 (1890).

Bauhinia altefissa Léveillé, Fl. Kouy-Tchéou, 226 (1914); Cat. Pl. Yun-Nan, 152 (1916).—**Synon. nov.**

CHINA. K w e i c h o u: Mou-you-se, *J. Cavalerie*, no. 3908, June 1912 (syntype of *B. altefissa;* photo. in A. A.); without locality, *J. Esquirol*, no. 511 (syntype of *B. altefissa;* photo. in A. A.).

Bauhinia altefissa agrees perfectly with *B. yunnanensis*, but Esquirol's no. 3056 "derrière le camp de Lo-hou, Juillet 1911" cited by Léveillé under the original description of *B. altefissa* does not belong here; the specimen is sterile and probably belongs to *B. densiflora* Franch.

Bauhinia aurea Léveillé in Bull. Soc. Bot. France, LIV. 368 (1907); Fl. Kouy-Tchéou, 226 (1914).

CHINA. K w e i c h o u: rochers et bois des environs de Lo-fou, *J. Cavalerie*, no. 2614, Nov. 1905 (holotype; photo. in A. A.); Pin-fa, *J. Cavalerie*, no. 2614; Lao-ten, *E. Bodinier*, no. 43; Ou-la-gay, *J. Seguin;* confluent des deux rivières de Lo-kouy; *J. Esquirol*, no. 3226, 1898–1912. (All enumerated by Léveillé, Fl. Kouy-Tchéou.)

This species resembles in the size, tomentum and general outline of the leaf *B. Vahlii* Wight et Arn., but differs in the somewhat acutish not rounded lobes, and in the narrow, not open, basal sinus; also the pod which I have not seen agrees according to the description with that of *B. Vahlii*. I have not seen the additional specimens cited in the Flore du Kouy-Tchéou. A similar form also only in fruit has been collected in Kweichou by Y. Tsiang (no. 7289) near Gan-wu, Lo-hu on the Kwangsi border, but the leaves are subcordate to nearly truncate at base, while the lobes are acutish.

Pterolobium punctatum Hemsley in Jour. Linn. Soc. XXIII. 207 (1887).

Prosopis Esquirolii Léveillé, Fl. Kouy-Tchéou, 242 (1914).—**Synon. nov.**

CHINA. K w e i c h o u: de Tong-fong-tcheou à Sy-pou-ho, *J. Esquirol*, no. 166, Aug. 1904 (holotype of *Prosopis Esquirolii;* merotype in A. A.).

Sophora japonica Linnaeus, Mant. I. 68 (1767).—Léveillé, Fl. Kouy-Tchéou, 243 (1914); Cat. Pl. Yun-Nan, 161 (1916).

Ormosia Esquirolii Léveillé, Fl. Kouy-Tchéou, 240 (1914).—**Synon. nov.**

Sophora Mairei Léveillé in Bull. Géog. Bot. XXV. 48 (1915); non *S. Mairei* Pamp. (1910).—**Synon. nov.**

China. Kweichou: Lao-ouang-tchai, *J. Esquirol*, no. 3840, July 1912, "arbre 6 m.; fl. blanches" (holotype of *Ormosia Esquirolii;* merotype in A. A.). Yunnan: plaine de Tong-tchouan, alt. 2500 m., *E. E. Maire*, Aug. [1911–14], "gros et grand arbre; fleurs blanches inodores" (holotype of *S. Mairei;* merotype in A. A.).

Sophora glauca De Candolle in Ann. Sci. Nat. ser. 1, iv. (1824) 98 (1825).—Gagnepain in Lecomte, Not. Syst. iii. 117 (1915).—Léveillé, Cat. Pl. Yun-Nan, 161 (1916).

Indigofera Mairei Léveillé in Fedde, Rep. Spec. Nov. xii. 190 (1913).

China. Yunnan: couteaux calcaires arides, derrière La-kou, 2450 m., *E. E. Maire*, June 1911, "fleurs violettes" (syntype of *Indigofera Mairei;* photo. in A. A.); plaine de Kiao-kia, alt. 400 m., *E. E. Maire*, July 1911, "fleurs violettes" (syntype of *Indigofera Mairei;* photo. in A. A.).

Indigofera Mairei has been identified already by Gagnepain (l. c.) with *Sophora glauca*.

Sophora glauca var. **albescens** Rehder in Sargent, Pl. Wilson. iii. 447 (1917).

Sophora Cavaleriei Léveillé, Fl. Kouy-Tchéou, 242 (1914).—**Synon. nov.**

China. Kweichou: Hin-y-fou, *J. Cavalerie*, no. 3909, June 1912 (holotype of *S. Cavaleriei;* photo. in A. A.).

Cavalerie's no. 3909 is somewhat less pubescent than *S. glauca* usually is. Var. *albescens* is apparently a mere color-form; the differences in the shape of the leaflets given in the original description do not seem to hold. Both forms, with violet and with yellowish white flowers, occur in Szechuan as well as in Yunnan.

Maackia Fauriei (Lévl.) Takeda in Not. Bot. Gard. Edinb. viii. 101, t. 27, fig. 39–43 (1913).

Cladrastis Fauriei Léveillé in Fedde, Rep. Spec. Nov. vii. 230 (1909).

Korea. Quelpaert: Hallaisan, 1200 m., *U. Faurie*, no. 1692, Aug. 1907 (holotype of *C. Fauriei;* isotype in A. A.).

Indigofera stachyodes Lindley in Bot. Reg. i. t. 14 (1843).

Indigofera Bodinieri Léveillé in Fedde, Rep. Spec. Nov. xii. 190 (1913).—Gagnepain in Lecomte, Not. Syst. iii. 117 (1915), pro synon. *Indigoferae dosua* Buch.-Ham.

Indigofera Dosua Buch.-Ham. var. *stachyodes* (Lindl.) Léveillé, Fl. Kouy-Tchéou, 234 (1914).

China. Kweichou: dans la montagne aux environs de Ganpin, *Léon Martin* et *E. Bodinier*, no. 1822, Sept. 24, 1897 (syntype of *I. Bodinieri;* photo. in A. A.); Tsin-gay à Tong-mou-lin, *E. Bodinier*, no. 1822 bis, June 24, 1899 (syntype of *I. Bodinieri;* photo. in A. A.).

Indigofera Dosua Buch.-Ham. listed by Léveillé in his Cat. Pl. Yun-Nan (p. 156) probably also refers to *I. stachyodes* Lindl. (*I.*

Dosua var. *tomentosa* Bak.) and not to typical *I. dosua* Buch.-Ham., of which I have seen no specimens from Yunnan.

Indigofera Esquirolii Léveillé in Fedde, Rep. Spec. Nov. XII. 190 (1913); Fl. Kouy-Tchéou 234 (1914).—Gagnepain in Lecomte, Not. Syst. III. 117 (1915).

CHINA. Kweichou: Ouang-mou, *J. Esquirol*, no. 48, May 25, 1904 (holotype; photo. in A. A.); Tou-chan; Tsin-gay, bord de la rivière de Cha-téou-tche, *J. Cavalerie* in Herb. *Bodinier*, no. 2374, Nov. 1898 (cited in Fl. Kouy-Tchéou, l. c.).

This species seems nearest to *I. Dielsiana* Craib, but differs in its densely pubescent larger leaflets up to 3 cm. long, in the larger racemes up to 12 cm. long and shorter calyx-tube with longer lobes. Gagnepain (l. c.) also states that it seems to be a new species.

Indigofera Vanioti Léveillé, Cat. Pl. Yun-Nan, 157 (1916), excl. specim. e Lou-pou.

Fruticulus ramosus, 40 cm. altus; ramuli ut pedunculus et rhachis racemi pilis mediofixis albidis et sparsius glandulis fulvis conspersi. Folia 7–9-foliolata, cum petiolo 5–8 mm. longo ut rhachis sparse pilis mediofixis et glandulis paucis instructo ad 3 cm. longa; stipulae 2 mm. longae; foliola opposita, oblonga vel obovato-oblonga, 6–9 mm. longa et 2–3.5 mm. lata, vel interdum in folius minoribus ovalia vel obovata, apice rotundata et mucronulata, basi rotundata vel late cuneata, supra glabra vel interdum pilis mediofixis paucis instructa et intense viridia, subtus pallida et pilis mediofixis conspersa, nervis obsoletis, petiolulo ad 1 mm. longo suffulta; stipellae saepe petiolulum fere aequantes. Racemi ad 5 vel 6 cm. longi, pedunculo 5–10 mm. longo suffulti; bracteae deciduae at 2 mm. longae; pedicelli 1 mm. longi ut calyx pilis mediofixis obtecti; flores violacei; calycis tubus circiter 1 mm., lobus infimus subulatus 1.75 mm. longus; vexillum 6–7 mm. longum et 3.5–4 mm. latum, apice rotundatum, minute mucronulatum, extus dense pubescens; alae 6 mm. longae et 1.5 latae, superne ciliolatae, carina 6.5 mm. longa superne extus pubescens, auriculis quam unguiculi multo brevioribus; ovarium glabrum.

CHINA. Yunnan: pâturages du mont Tsouan-tien-po, alt. 2700 m., *E. E. Maire*, May [1911–12] "fl. violettes" (syntype of *I. Vanioti:* merotype in A. A.).

Léveillé enumerates under his *I. Vanioti* two specimens. He compares his new species with *I. Hosiei* and *I. lenticellata* and states that it differs "a primo stipellis conspicuis; a secundo lenticellis nullis. Flores violacei, 0.40 cm. alta." This is all the description he gives. The two specimens Léveillé cites are not identical, and

only one, the specimen cited above, has stipels which could be called conspicuous, the other specimen from Lou-pou has no noticeable stipels and I consider it identical with *I. szechuensis* Craib. I therefore take the specimen from Tsouan-tien-po as the type of Léveillé's species, though the label is without name, and have given above a description of *I. Vanioti* based on this specimen. It differs from *I. szechuensis* and from *I. Hosiei* and *I. lenticellata* at the first glance by the leaflets being glabrous or nearly so above. It seems nearest related to *I. Silvestrii* Pamp. which is readily distinguished according to the description by the smaller flowers with the wings exceeding the standard and the white-pubescent ovary; I have seen no specimen of *I. Silvestrii*.

Indigofera szechuensis Craib in Notes Bot. Gard. Edinb. VIII. 62 (1913).

Indigofera Vanioti Léveillé, Cat. Pl. Yun-Nan, 157 (1916), quoad specimen e Lou-pou.

CHINA. Yunnan: vallée de Lou-pou, alt. 3000 m., *E. E. Maire*, June [1911–12] "fl. violettes" (syntype of *I. Vanioti;* merotype in A. A.).

This specimen agrees well with the type of *I. szechuensis* except that the leaflets are somewhat narrower and number only 7–9. It bears the name *I Vanioti* in Léveillé's handwriting on the label, while the specimen which I consider the type of *I. Vanioti* has no name on its label, but both specimens were placed in the cover of *I. Vanioti* in Léveillé's herbarium.

Indigofera reticulata Franchet, Pl. Delavay. 153 (1889).

Indigofera Craibiana Léveillé, Cat. Pl. Yun-Nan, 155 (1916).—**Synon. nov.**

CHINA. Yunnan: monticule calcaire de Kin-tchong-chan, alt 2550 m., *E. E. Maire*, Aug. [1911–12] (syntype of *I. Craibiana;* merotype in A. A.); pâturages de montagnes à Tong-tchouan, alt. 2600 m., *E. E. Maire* (ex Léveillé; syntype of *I. Craibiana*).

Indigofera atropurpurea Buchanan-Hamilton apud Roxburgh, Hort. Bengal. 57 (1814), nomen; Fl. Ind. III. 381 (1832).—Léveillé, Fl. Kouy-Tchéou, 234 (1914).

Indigofera Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. XII. 190 (1913).—Gagnepain in Lecomte, Not. Syst. III. 117 (1914), pro synon. *I. atropurpureae.*

CHINA. Kweichou: Tsin-gai, bord du ruisseau, *J. Cavalerie*, no. 1191, July 1903 (holotype; photo. in A. A.).

Indigofera Cavalerie was identified with *I. atropurpurea* in 1914 by Gagnepain (l. c.) and in the same year enumerated by Léveillé in his Flore du Kouy-Tchéou (l. c.) as *I. atropurpurea*, but without citation of *I. Cavaleriei* as a synonym, though its type, Cavalerie no. 1191, is cited with the addition of Cavalerie no. 2672.

Millettia Dielsiana Harms in Bot. Jahrb. XXIX. 412 (1900).
Millettia Blinii Léveillé, Fl. Kouy-Tchéou, 238 (1914).—**Synon. nov.**
Millettia Bodinieri Léveillé, l. c.—**Synon. nov.**
Millettia Dunniana Léveillé, Cat. Pl. Yun-Nan, 159 (1916).—**Synon. nov.**
Millettia fragrantissima Léveillé, Fl. Kouy-Tchéou, 239 (1914).—**Synon. nov.**

CHINA. Kweichou: Tang-tchang, *J. Esquirol*, no. 1568, June 1909 (holotype of *M. Blinii;* photo. in A. A.); Gan-pin, Kouy-yang, *L. Martin* in herb. E. Bodinier, no. 2391, June 1896 and 1897, "branches en liane, trainant sur les rochers, fleurs pourpres (Gay-téou)" (holotype of *M. Bodinieri;* photo. in A. A.); Tsin-gai, *J. Cavalerie*, no. 1133, July 14, 1903, "fl. rouge-rose à l'ext., sens delicieux" (holotype of *M. fragrantissima;* photo. in A. A.). Yunnan: brousse, rives des fleuve Bleu, alt. 400 m., *E. E. Maire*, July 1912, "fleurs roses" (holotype of *M. Dunnii;* photo. in A. A.).

The specimens cited above which are all flowering belong apparently to the variable *M. Dielsiana* which varies in the shape and in the pubescence of the leaves; in *M. fragrantissima* and *M. Blinii* the leaves are glabrous beneath, in *M. Bodinieri* and *M. Dunniana* pubescent.

Millettia Gentiliana Léveillé, Fl. Kouy-Tchéou, 239 (1914).

CHINA. Kweichou: Pin-fa, descente de Kouan-lin, *J. Cavalerie*, no. 644, June 10, 1904 (holotype; merotype in A. A.).

This species seems near *M. cinerea* Benth., but as the latter species has not yet been recorded from Kweichou, I hesitate to identify *M. Gentiliana*, which is only represented by a fruiting specimen, definitively with *M. cinerea*.[1]

Caragana Franchetiana Komarov in Act. Hort. Bot. Petrop. XXIX. 300, t. 13A (1908).
Caragana Komarovi Léveillé, in Bull. Géog. Bot. XXV. 49 (1915).—**Synon. nov.**

CHINA. Yunnan: rochers des montagnes de Lou-pou et Tong-tchouan, alt. 2800–3200 m., *E. E. Maire*, July 1912, "arbuste épineux buissonant, fleurs papil. jaunes" (holotype of *C. Komarovi;* merotype in A. A.).

Caragana Komarovi is an extreme form of the variable *C. Franchetiana* with strong spines up to 6 mm. long and with less pubescent and more numerous leaflets (up to 9 pairs).

Desmodium racemosum (Thunb.) De Candolle, Prodr. II. 337 (1825).—Schindler in Fedde, Rep. Spec. Nov. Beih. XLIX. 227 (Desmodiinae) (1928).
Desmodium Bodinieri Léveillé, Fl. Kouy-Tchéou, 232 (1914).

[1] *Millettia Esquirolii* Léveillé, Fl. Kouy-Tchéou, 239 (1914) is not a *Millettia*, from which it differs in its alternate estipellate leaflets and racemose flowers; it may belong to *Pongamia* or *Derris*, but in the absence of fruits its position remains doubtful.

China. Kweichou: Kouy-yang; mont. du Collège; Gan-pin; *E. Bodinier*, no. 1753 (ex Léveillé; syntypes; photo. in A. A.).

Of *D. Bodinieri* there is at present but one specimen in the Herbarium Léveillé, without collector or locality, only with a label bearing the name "*D. Bodinieri* Lévl." in Léveillé's handwriting. In a note appended to the genus in the Flore du Kouy-Tchéou Léveillé states that the localities given under the species of this genus are incomplete or lacking, since the specimens were at that time in the hands of Dr. Diels. The fruit of Bodinier's specimen is pubescent, not glabrous as described by Thunberg and De Candolle.

Desmodium cinerascens Franchet, Pl. Delavay. 174 (1890).

Desmodium Esquirolii Léveillé, Fl. Kouy-Tchéou, 232 (1914); Cat. Pl. Yun-Nan, 154 (1916).—**Synon. nov.**

China. Kweichou: without locality, *J. Cavalerie*, no. 3274 (ex Léveillé; holotype of *D. Esquirolii*); without locality, *J. Cavalerie*, no. 3998 (in herb. Léveillé under *D. Esquirolii*). Yunnan: mont. de Ta-choui-tsin, alt. 2300 m., *E. E. Maire*, June [1911–12], "arbuste, feuil. caduques, fl. violettes" (in herb. Léveillé under *D. Esquirolii*).

On the sheet of Maire's Yunnan specimen there are two specimens of which that with less pubescent leaves may not belong to *D. cinerascens*. *Desmodium cinerascens* seems to vary greatly in the amount of pubescence; all the specimens in this herbarium referred by Schindler to *D. cinerascens* are much more pubescent than Franchet's type.

Desmodium gyroides (Roxb.) De Candolle, Prodr. II. 326 (1825).

Desmodium oxalidifolium Léveillé, Fl. Kouy-Tchéou, 233 (1914), pro parte.—**Synon. nov.**

China. Kweichou: Lo-fou, couteaux, alt. 600 m., *J. Esquirol*, no. 2205, Sept. 1910, "couleur violette" (syntype of *D. oxalidifolium*, in part; photo. in A. A.).

The other specimen cited by Léveillé under *D. oxalidifolium* belongs to the following species.

Desmodium Griffithianum Bentham in Junghuhn, Pl. Junghuhn. 222 (1852).—Schindler in Fedde, Rep. Spec. Nov. Beih. XLIX. 227 (Desmodiinae) (1928).

Desmodium oxalidifolium Léveillé, Fl. Kouy-Tchéou, 233 (1914), pro parte.

China. Kweichou: Tong-kia-tchao; Tsin-tchen, *E. Bodinier*, no. 1731 (ex Léveillé; syntype of *D. oxalidifolium*); without locality, "no. 42" (in Herb. Léveillé sub *D. oxalidifolium;* photo. in A. A.).

Bodinier's no. 1731 is not now in the Herb. Léveillé but there is a specimen without locality and collector, labeled *D. oxalidifolium* in

Léveillé's handwriting, which agrees with Léveillé's description, while the other syntype cited under the preceding species does not fit the description.

Desmodium concinnum De Candolle, Prodr. II. 335 (1825).

Desmodium barbigerum Léveillé, Pl. Cat. Yun-Nan, 153 (1916).—**Synon. nov.**

CHINA. Yunnan: pâtures des couteaux arides à Ou-long-mo, alt. 2550, *E. E. Maire*, July [1911–12] "vivace en touffes, mi-rampante, fl. violettes" (syntype of *D. barbigerum*); pâtures des couteaux à Ma-gan-chan, alt. 2550 m., *E. E. Maire*, Aug. (1911–12), "vivace, couchée" (syntype of *D. barbigerum;* photo. in A. A.).

Maire's specimens differ from the material of *D. concinnum* before me in the darker colored flowers with purple calyx. The plant also seems to differ in its habit; Maire describes it as a procumbent or nearly creeping perennial, while according to the description of the Himalayan plant it is a tall shrub with pendulous branches.

Desmodium gangeticum (L.) De Candolle, Prodr. II. 327 (1825).—Schindler in Fedde, Rep. Spec. Nov. Beih. XLIX. 227 (Desmodiinae) (1928).

Desmodium Cavaleriei Léveillé, Fl. Kouy-Tchéou, 232 (1914).

CHINA. Kweichou: without locality, *J. Cavalerie*, no. 3274, (holotype; photo. in A. A.).

Lespedeza Forrestii Schindler in Notes Bot. Gard. Edinb. VIII. 13, t. 8 (1913).

Lespedeza Pampaninii Léveillé in Bull. Géog. Bot. XXV. 48 (1915); Fl. Kouy-Tchéou, 158 (1916).—**Synon. nov.**

CHINA. Yunnan: pâturages de Io-chan, alt. 3200 m., *E. E. Maire*, June 1912, "polygonum vivace rampant, fleurs rouges" (holotype of *L. Pampaninii;* merotype in A. A.)

Lespedeza Monnoyeri Léveillé, Cat. Pl. Yun-Nan, 158 (1916).

CHINA. Yunnan: terrains arides, collines derrière La-kou, alt. 2400 m., *E. E. Maire*, July 1912, "legum. vivace rampant, fleurs roses" (holotype; merotype in A. A.).

Very distinct with its broadly ovate or almost obcordate leaflets and the rather long-peduncled flowers.

Lespedeza daurica (Laxm.) Schindler in Fedde, Rep. Spec. Nov. XXII. 274 (1926).

Lespedeza trichocarpa Persoon, Syn. Pl. II. 318 (1807).—Schindler in Bot. Jahrb. XLIX. 607 (1913).

Lespedeza Fauriei Léveillé in Fedde, Rep. Spec. Nov. VII. 230 (1909).

KOREA: in herbidis Chinnampo, *U. Faurie*, no. 415, Aug. 1906 (holotype of *L. Fauriei;* photo. and isotype in A. A.).

According to notes on the sheet of the type specimen of *L. Fauriei* it was identified as *L. trichocarpa* in 1910 by Pampanini and in 1912 by Schindler; the isotype in this herbarium also was identified in 1912 by Schindler as *L. trichocarpa* and the identification published in 1913 (l. c.).

Lespedeza striata (Thunb.) Hooker & Arnott, Bot. Voy. Beechey, 262 (1841).—Léveillé, Cat. Pl. Yun-Nan, 159 (1916).

Trifolium ? polygonum Léveillé in Fedde, Rep. Spec. Nov. XII. 282 (1913).

CHINA. Yunnan: plaine et montagne a Tche-hai, alt. 2500–2600 m., E. E. Maire, July 1912 (holotype of *Trifolium polygonum;* photo. in A. A.).

Trifolium polygonum was referred to *Lespedeza striata* by Léveillé in 1916 (l. c.).

Campylotropis polyantha (Franch.) Schindler in Fedde, Rep. Spec. Nov. XI. 340 (1912).

Lespedeza Blinii Léveillé in Bull. Bot. Géog. XXV. 48 (1915); Cat. Pl. Yun-Nan, 157 (1916).—**Synon. nov.**

Lespedeza dichromocalyx Léveillé, Fl. Kouy-Tchéou, 236 (1914); Cat. Pl. Yun-Nan, 157 (1916).—**Synon. nov.**

CHINA. Kweichou: monts entre Hin-y-hien et Hin-y-fou, *E. Bodinier*, no. 2279, April 12, 1897 (syntype of *Lespedeza dichromocalyx;* merotype in A. A.); Gan-chouen, *J. Cavalerie*, no. 3997, Aug. 28, 1912 (syntype of *L. dichromocalyx;* merotype in A. A.). Yunnan: environs de Yunnan-sen, bords de canaux, des routes, *E. Bodinier*, March 11, 1897 (syntype of *L. dichromocalyx;* merotype in A. A.); commun sur les rives rocheuses du fleuve Bleu à Mong-kou, alt. 500 m., E. E. Maire, April (1911–14) (holotype of *Lespedeza Blinii;* photo. in A. A.).

Campylotropis velutina (Dunn) Schindler in Fedde, Rep. Spec. Nov. XX. 286 (1924).

Millettia Cavaleriei Léveillé, Fl. Kouy-Tchéou, 238 (1914).—**Synon. nov.**

CHINA. Kweichou: Lo-kouen, ouest de Lo-fou, *J. Cavalerie*, no. 2754, Apr. 1906, "fl. blanches" (holotype of *Millettia Cavaleriei;* photo. in A. A.); Lo-fou, *J. Cavalerie*, no. 3683, Apr. 1909, "fl. blanches violacées" and *J. Cavalerie*, no. 1406 (both in cover of *M. Cavaleriei* in herb. Léveillé; duplicates in A. A.).

Dalbergia Esquirolii Léveillé, Fl. Kouy-Tchéou, 230 (1914).

CHINA. Kweichou: Hoang-tsao-po, colline de la pagode, *J. Esquirol*, no. 1351, June 5, 1909 (holotype; photo. in A. A.).

This species seems near *D. Dyeriana* Prain, but differs in the narrow-oblong leaflets 1.5–3 cm. long and 6–9 mm. broad, and narrowed toward the obtuse apex, in the terminal inflorescence and in the calyx being nearly glabrous except the ciliate lobes.

Dalbergia Cavaleriei Léveillé, Fl. Kouy-Tchéou, 230 (1914).

CHINA. Kweichou: Hoa-kiang et descente du même fleuve, *J. Cavalerie*, no. 3918, June 1912 (syntype; photo. in A. A.).

Similar to *D. mimosoides* Franch. and *D. stenophylla* Prain, but easily distinguished by the leaflets being appressed-pubescent on both sides. The same species has been collected in Kweichou also by Handel-Mazzetti (no. 10352).

Derris spec. Léveillé, Fl. Kouy-Tchéou, 231 (1914).

Indigofera Thirionni Léveillé in Fedde, Rep. Spec. Nov. XII. 190 (1913).—Gagnepain in Lecomte, Not. Syst. III. 117 (1915), pro synon. Derris vel Millettiae spec.

CHINA. Kweichou: Ouang-mou, *J. Esquirol*, no. 117, June 1904, "petit arbrisseau, fl. rose" (holotype of *I. Thirionni;* photo. in A. A.).

The specimen consists of flowering branches with all the leaflets and most of the flowers fallen off and some young leaflets and flowers in a pocket and is too meagre for exact determination. Gagnepain in a note on the type specimen refers it doubtfully to *Derris* or perhaps *Millettia;* according to its inflorescence and flowers it seems to be a *Derris*.

Dumasia villosa De Candolle, Mém. Fam. Legum. 257, t. 44 (1825); Prodr. II. 241 (1825).

Erythrina Mairei Léveillé in Bull. Géog. Bot. XXV. 50 (1915); Cat. Pl. Yun-Nan, 155 (1916).—**Synon. nov.**

Apios Mairei Lévl. in herb. Léveillé, l. c. (1915), pro synon.

CHINA. Yunnan: sous bois de Pan-lang-se, alt. 2500 m., *E. E. Maire*, Sept. (1912) "plante grimpante vivace, fl. jaune d'or" (holotype; photo. in A. A.).

Mucuna terrens Léveillé in Fedde, Rep. Spec. Nov. XIII. 264 (May 5, 1914).

Mucuna corvina Gagnepain in Lecomte, Not. Syst. III. 28 (May 24, 1914).—Léveillé, Fl. Kouy-Tchéou, 240 (1914).

CHINA. Southern Kweichou: without precise locality, *J. Cavalerie*, no. 2974, April 1908 "grande liane à fleur noire" (ex Léveillé; holotype of *M. terrens*); Gan-chouen, *J. Cavalerie*, nos. 3782, 3785?, May and Dec. 1910 (ex Gagnepain; syntypes of *M. corvina*).

In his Flore du Kouy-Tchéou Léveillé cites his *M. terrens* as a synonym of *M. corvina*, though it has priority by about 10 days over the latter name. I have here united the two names on the authority of Léveillé, since I have seen neither Léveillé's nor Gagnepain's specimens.

Mucuna Bodinieri Léveillé in Bull. Soc. Bot. France, LV. 408 (1908); Fl. Kouy-Tchéou, 240 (1914).

China. Kweichou: dans un bois de pagode, non loin du fleuve Hoa-kiang, *E. Bodinier*, no. 2282, April 21, 1897, "grande liane . . . fleurs naissant seules sur le vieux bois" (syntype; photo. and merotype in A. A.); environs de Hoa-ko-chon, *J. Seguin*, April 6, 1898 (ex Léveillé; syntype).

This species resembles *M. pruriens* DC., but is at once distinguished by its 7–8 cm. long corolla.

Mucuna cochinchinensis (Lour.) A. Chevalier in Bull. Agr. Inst. Sci. Saigon, I. 91 (1919).

Mucuna Martini Léveillé in Bull. Soc. Bot. France, LV. 409 (1908); Fl. Kouy-Tchéou, 240 (1914).—**Synon. nov.**

China. Kweichou: environs de Ou-la-cay (Tchen-lin-tcheou), dans les buissons, *L. Martin* et *E. Bodinier*, no. 1984 "fleurs blanches en grappes" (holotype of *M. Martini;* photo. in A. A.).

This species has not yet been recorded from China, but I have little doubt that *M. Martini* is referable to it; it agrees well in leaf, fruit and flower with specimens distributed by Merrill as *M. cochinchinensis* and as *M. nivea* (Roxb.) Wight & Arn. which is a synonym of the former according to Merrill.

Mucuna Esquirolii Léveillé in Fedde, Rep. Spec. Nov. VII. 231 (1909); Fl. Kouy-Tchéou, 240 (1914).

China. Kweichou: without locality, *J. Esquirol*, no. 885 (holotype; merotype in A. A.).

This species is chiefly characterized by the leaflets being pubescent on both sides, more densely beneath, with accumbent long white hairs, the middle leaflets elliptic-ovate and broadly cuneate at the base, by the rather small flowers with slightly curved keel and long calyx-teeth, the lower one longer than the short about 5 mm. long calyx-tube. Fruit wanting.

Mucuna sempervirens Hemsley in Jour. Linn. Soc. XXIII. 190 (1887).—Léveillé, Fl. Kouy-Tchéou, 240 (1914).

Mucuna Mairei Léveillé in Fedde, Rep. Spec. Nov. XIII. 337 (1914); Cat. Pl. Yun-Nan, 116 (1916).—**Synon. nov.**

China. Yunnan: forêt de San-tao-keou, 2450 m., *E. E. Maire*, May, 1913, "fleurs violet-sombre" (holotype of *M. Mairei;* merotype in A. A.).

Pueraria Thunbergiana (Sieb. & Zucc.) Bentham in Jour. Linn. Soc. IX. 122 (1867).—Léveillé, Fl. Kouy-Tchéou, 241 (1914); in Mem. Acad. Ci. Art. Barcelona, ser. 3, XII. no. 22, p. 15 (Cat. Pl. Kiang-Sou) (1916).

Pueraria Bodinieri Léveillé & Vaniot in Bull. Soc. Bot. France, LV. 425 (1908); Fl. Kouy-Tchéou, 241 (1914).—**Synon. nov.**

Pueraria Koten Léveillé in Bull. Soc. Bot. France, LV. 426 (1908).—**Synon. nov.**

Pueraria Argyi Léveillé & Vaniot in Bull. Soc. Bot. France, LV. 426 (1908).—Léveillé in Mem. Acad. Ci. Art. Barcelona, ser. 3, XII. no. 22, p. 15 (Cat. Pl. Kiang-Sou) (1916).—**Synon. nov.**

Pueraria coerulea Léveillé & Vaniot in Bull. Soc. Bot. France, LV. 427 (1908).—**Synon. nov.**

CHINA. S h a n t u n g: Chefu, *E. Bodinier*, Sept. 10, 1889 (holotype of *P. Koten;* photo. in A. A.). K i a n g s u: without precise locality, *Ch. d'Argy*, no. 51 [1846–66] (holotype of *P. Argyi;* merotype in A. A.). K w a n g t u n g: Hongkong: baie de Chay-ouan, *E. Bodinier*, no. 1358, Oct. 17, 18 (holotype of *P. coerulea;* merotype in A. A.). K w e i c h o u: environs de Kouy-yang, mont du Collège, dans les rocailles, les herbes, les haies, *E. Bodinier*, no. 2489, Sept. 9, 1898 (holotype of *P. Bodinieri*, photo. in A. A.).

All four species described as new by Léveillé seem to be slight variations of the widely distributed *P. Thunbergiana;* the specimen of *P. Koten* looks rather distinct on account of its smaller three-lobed leaflets.

Dunbaria pulchra Bentham in Hooker, Fl. Brit. Ind. II. 218 (1879).—Léveillé, Cat. Pl. Yun-Nan, 154 (1916); China Rev. Ann. 1916, p. 21.

Pueraria Seguini Léveillé in Bull. Soc. Bot. France, LV. 426 (1908); Fl. Kouy-Tchéou, 241 (1914).

CHINA. K w e i c h o u: environs de Hoang-ko-chou, *J. Seguin*, no. 2446, July 10, 1898, "liane herbacée trainant sur les rochers (Siao-ko-ten), fleurs jaunes" (holotype of *P. Seguini;* photo. in A. A.).

Pueraria Seguini was referred to *Dunbaria pulchra* as a synonym by Léveillé himself in 1916.

(*To be continued.*)

HERBARIUM, ARNOLD ARBORETUM
HARVARD UNIVERSITY

NOTULAE SYSTEMATICAE AD FLORAM SINENSEM IV.[1]

H. H. Hu

Carpinus Chowii, sp. nov.

Arbor ad 5 m. alta; rami cinereo-brunnei, glabri; gemmae conico-ovoideae, 4 mm. longae, acutae, rufescentes, glabrae, perulis numerosis obtusiusculis ciliolatis. Folia ovata, circiter 3.5 cm. longa et 2 cm. lata, acuta, basi rotundata vel interdum subcuneata, grosse et subsimpliciter dentato-serrata dentibus mucronulatis, supra costa media puberula excepta glabra, subtus costa venisque pilosis et axillis barbulatis exceptis glabra, venis utrinsecus 8–10 et 2.5–3 mm. distantibus; petioli graciles, ad 8 mm. longi, puberuli. Infructescentia satis densa, ad 3 cm. longa, pedunculo 1.5 cm. longo; bracteae chartaceae, semi-ovatae, 10–12 mm. longae et 6–9 mm. latae, reticulatae, in latere convexo grosse et sparse lobato-dentatae dentibus 4–5 magnis, in latere recto interdum ad apicem serrato et basi lobo inflexo parvo in bracteis sterilibus deficiente instructae; nuculae late ovoideae, 4 mm. longae, glabrae, leviter costatae.

Tree to 5 m. high; branchlets grayish brown, glabrous; buds ovate-conical, acute, reddish, glabrous, 4 mm. long, with many imbricate obtusish ciliolate scales. Leaves ovate, acute, rounded or sometimes subcuneate at base, coarsely and subsimply mucronate-dentate-serrate, glabrous except puberulous along the midrib above, glabrous except pubescent along the midrib and lateral veins and with axillary tufts of hairs beneath, veins 8–10 pairs, 2.5–3 mm. distant, lamina to 3.5 cm. long, 2 cm. broad; petiole slender, puberulous, to 8 mm. long. Infructescence rather dense, to 3 cm. long, peduncle 1.5 cm. long; bracts chartaceous, semiovate, reticulate, 10–12 mm. long, 6–9 mm. broad, convex side coarsely and sparsely lobate-dentate with 4–5 large teeth, straight side occasionally serrate at apex, with a minute inflexed lobe at base; nutlet broadly ovoid, glabrous, slightly ribbed.

HOPEI: Fang-shan, alt. 500 m., common, *H. F. Chow*, no. 41730 (type), Oct. 5, 1931.

A very distinct species of the section Eucarpinus characterized chiefly by the rather small loosely veined, coarsely and nearly simply dentate-serrate leaves with mucronate teeth and coarsely and sparsely lobate-dentate fruiting bracts. *Carpinus Chowii* is

[1] For I–III. see Vol. XI. 48–50, 224–228; XII. 151–156.

apparently closely allied to *C. Turczaninowii* Hance var. *ovalifolia* Winkler, but the latter differs in more closely doubly serrate leaves and much more finely serrate but not lobulate bracts.

689 **Carpinus Chuniana**, sp. nov.

Arbor; ramuli graciles, pubescentia villosa flavescente vestiti; gemmae globosae, 1 mm. diam., perulis paucis rotundatis imbricatis. Folia membranacea, firma, ovata vel elliptico- ad oblongo-ovata, 8–11 cm. longa et 4–6 cm. lata, acuta vel breviter acuminata, basi cordata, irregulariter et breviter duplicato-serrata vel subsimpliciter serrata, supra costa puberula excepta glabra, subtus costa nervisque pilosis et axillis barbulatis exceptis glabra, utrinque glanduloso-punctata et reticulata, nervis utrinsecus 15–16 et 5–8 mm. distantibus trabeculis satis congestis conjunctis, petioli 8–10 mm. longi, villosuli. Infructescentia densa, 8–11 cm. longa et ad 4 cm. lata, rhachi sericeo-villosula, pedunculo ad 3 cm. longa villosulo; bracteae dense imbricatae, late semi-ovatae, ad 2.5 cm longae et 1.3 cm. latae, acutae, in latere convexo breviter dentato-serratae, in latere recto remote serrulatae et basi leviter inflexae, reticulatae, utrinque in costa hirtellae; nuculae leviter compressae, subgloboso-ovoideae, 4 mm. longae et latae, conspicue 8-costatae, glabrae et glandulis resinosis aurantiacis conspersae.

Tree; young branchlets slender, yellowish villous-pubescent; buds globose, 1 mm. in diam., with few imbricate rounded scales. Leaves membranaceous, firm, ovate or ovate-elliptic to ovate-oblong, acute to shortly acuminate, cordate at base, shallowly and irregularly doubly or nearly simply serrate, glabrous except puberulous along the midrib above, glabrous except pilose along the midrib and veins and with axillary tufts of hairs beneath, glandulose-punctate and reticulate on both surfaces, 8–11 cm. long, 4–6 cm. broad, veins 15–16 pairs, 5–8 mm. distant; petiole 8–10 mm. long, villous-tomentulose. Infructescence dense, 8–11 cm. long, to 4 cm. broad, rachis sericeous-villosulous, peduncle slender, to 3 cm. long, villosulous; bracts densely imbricate, broadly semi-ovate, acute, convex side shallowly dentate-serrate, straight side remotely serrate and slightly inflexed at base, to 2.5 cm. long, 1.3 cm. broad, reticulate, sparsely hirtellous along the midrib; nutlet slightly compressed, broadly rounded-ovate, 4 mm. long and broad, 8-ribbed, punctate with orange resinous glands, glabrous.

KWANGTUNG: Lokchang, *C. L. Tso*, no. 20872 (type), May 31, 1929.

A distinct species of the section Eucarpinus, characterized by the large reticulately veined leaves, long, dense infructescence and large bracts shallowly dentate-serrate on the convex side and

remotely dentate-serrate down to the base on the straight side. *Carpinus Chuniana* is closely allied to *C. Fargesiana* Winkl., but differs in the much larger cordate leaves and in the bracts being neither lobate-dentate on the convex side nor dentate-serrate to the base on the straight side.

Raphiolepis kwangsiensis, sp. nov.

Frutex; ramuli juniores glabri. Folia coriacea, lanceolata, circiter 6 cm. longa et 1.5 cm. lata, basi anguste cuneata et in petiolum marginatum circiter 1.5 cm. longum decurrentia, apice obtuse acuminata, obtuse remoteque serrata et leviter revoluta, supra lucide viridia, subtus fuscescentia, utrinque glabra et leviter reticulata rete leviter elevato, costa supra manifeste subtus leviter elevata. Panicula fructifera circiter 6 cm. longa et 4 cm. diam.; fructus globosus, pedicellatus, 7 mm. diam., niger.

Shrub; young branchlets glabrous, leaves coriaceous, lanceolate, narrowly cuneate and decurrent at base, obtusely acuminate at apex, remotely and obtusely serrate and slightly revolute along the margin, shining green and glabrous and reticulate with elevated midrib above, glabrous and finely reticulate with slightly elevated midrib beneath, about 6 cm. long, 1.3–1.6 cm. broad, petioles winged, about 1.5 cm. long. Flowers unknown. Fruiting panicles 6 cm. long, 4 cm. in diam.; fruits globose, pedicellate, black, 7 mm. in diameter.

Kwangsi: Me-kom, Seh-feng Dar-shan, S. Nanning, alt. 800 m., *R. C. Ching*, no. 8360 (type), Nov. 3, 1928.

Closely allied to *R. indica* Lindley, from which it differs in the lanceolate leaves.

Raphiolepis lanceolata, sp. nov.

Frutex; ramuli glabri. Folia coriacea, lineari-lanceolata, 2.5–6.5 cm. longa et 5–10 mm. lata, obtusa vel obtuse acuminata, basi cuneata et in petiolum 2–3 mm. longum marginatum decurrentia, glabra, valde remote et obtuse serrata et leviter revoluta, supra nitentia et rugosa, subtus laxe reticulata. Fructus globosus, 4 mm. diam., pedicellatus, niger.

Shrub; branchlets glabrous. Leaves coriaceous, linear-lanceolate, narrowly cuneate and decurrent at base, obtuse to obtusely acuminate at apex, shining green and glabrous and rugose with elevated midrib above, glabrous and slightly reticulate with prominent midrib beneath, very remotely and obtusely serrate and slightly revolute along the margin, 2.5–6.5 cm. long, 0.5–1 cm. broad; petioles winged, 2–3 mm. long. Fruits globose, black, pedicelled, 4 mm. in diam.

KWANGSI: Seh-feng Dar-shan, S. Nanning, alt. 775 m., *R. C. Ching*, no. 8060 (type). Oct. 21, 1928.

Closely allied to *R. gracilis* Nakai, from which it differs in its very narrow, remotely serrate, linear-lanceolate leaves and in its smaller fruits.

96 **Torricellia angulata** Oliv. var. **intermedia** (Harms), var. nov.

Torricellia intermedia Harms in Bot. Jahrb. XXIX. 507 (1900).—Wangerin in Engler, Pflanzenr. IV.–229, p. 33 (1910).

SZECHUAN: Nanchuan, T'ai-ho-tung, *Bock & Rosthorn*, no. 1542, Sept. 1891 (type of *T. intermedia* Harms); Mt. Omei, side of thicket, alt., 1800–2000 m., *F. T. Wang*, no. 23297, July 10, 1931 (tree); between Pai-kuo-wan and Moso-ying, *C. Schneider*, no. 620 (arborescent shrub to 4 m.). YUNNAN: "plaine de Tché-hai," alt. 2500 m., *E. E. Maire* (Arnold Arb. distr. no. 294); without precise locality, *G. Forrest*, no. 10910. HUNAN: "ad minas Hsi-kwangschan prope urbem Hsinhwa," alt. 300–900 m., *H. Handel-Mazzetti*, no. 11773, May 9, 1918. KWANGSI: Yeo-mar-shan, N. Hin-yen, alt. 1225 m., *R. C. Ching*, no. 7237, Aug. 31, 1928.

This variety differs from the type in the leaves being coarsely mucronate-dentate betweeen the lobes and in the usually sparingly pubescent or puberulous veins of the under surface. Though Wilson's no. 4611 from Taning-hsien, eastern Szechuan is somewhat intermediate between the type and the variety, as it has a few teeth between some of the lobes, the specimens cited above are decidedly different from the type in their leaves being coarsely toothed all around between the lobes and merit to be distinguished as a variety.

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NEW SPECIES, VARIETIES AND COMBINATIONS FROM THE HERBARIUM AND THE COLLECTIONS OF THE ARNOLD ARBORETUM[1]

ALFRED REHDER

Neillia hypomalaca, sp. nov.

Frutex gracilis metralis; ramuli leviter flexuosi, hornotini fulvo-hirsuto-villosi, leviter angulati, annotini rubro-fusci. Folii lamina ambitu triangulari-ovata, 3–4.5 cm. longa et 2.5–3 cm. lata, basi subcordata vel rotundata, inciso-lobulata utrinque lobulis 3–4 acutis serratis infimo 5–8 mm. longo, in caudam dimidiam laminam aequantem serratam attenuata, supra densiuscule vel sparsius accumbenti-pilosa, subtus molliter et satis dense accumbenti-pilosa et ad costam venasque dense patentim pilosa, nervis utrinque 4–5; petiolus 3–4 mm. longus, dense fulvo-hirsuto-villosus; stipulae oblongae, 5–6 mm. longae, fere glabrae. Racemi 3–4 cm. longi, 8–14-flori floribus roseis; rhachis ut pedunculus circ. 1 cm. longus dense pilosa; bracteae caducae, glabrescentes, pedicellum subaequantes; pedicelli 3–4 mm. longi, villoso-pilosi et sparse glandulosi; calycis tubus cylindricus 8–9 mm. longus, extus basin versus sparse glandulis breviter stipitatis et pilis sparsissime conspersus vel fere omnino glaber, intus laxe villosulus, lobi lanceolati, 5 mm. longi, longe mucronato-acuminati; petala rotundato-ovati, sepalis paullo breviora, ciliolata; stamina 15–20; ovarium unicum vel raro duo, glabrum, 4 mm. longum, in stylum basi sparse et longe pilosum attenuatum; ovula 4–5.

CHINA. Yunnan: Litiping range, Mekong-Yangtze divide, east of Weihsi, *J. F. Rock*, no. 9171, in 1923, shrub 3 ft., flowers pink (type); brousse des collines à Tong-tchouan, alt. 2550 m., *E. E. Maire* (Arnold Arb. distr. no. 429) May [1910–14?] "arbuste delicat, buissonnant, fl. couleur chair"; halliers des montagnes à Ou-long, alt. 2250 m., *E. E. Maire* (Arnold Arb. distr. no. 529) May [1910–14 ?], "arbuste delicat, peu rameux, fl. couleur chair"; haies et halliers des collines, alt. 2500 m., *E. E. Maire* (Arnold Arb. distr. no. 41), April [1910–14 ?] "arbuste delicat, buissonnant, fl. couleur chair"; in shady thickets on the Li-ti-ping, lat. 27° 12′ N., alt. 10000 ft., *G. Forrest*, no. 13883, June 1917 (shrub 3–4 ft.; flowers rose and white).

This species is apparently closely related to *N. sinensis* Oliver and to *N. villosa* W. W. Sm.; from the former it is easily distin-

[1] Continued from vol. XII. 78.

guished by the densely pubescent branches, rhachis and petioles, by the smaller subcordate and more deeply lobed leaves densely pubescent beneath and less so above and the shorter pedicels; from *N. villosa* it differs chiefly in the much smaller leaves, shorter petioles, narrower stipules, the presence of petals and the glabrous ovary. From *N. thibetica* Franch. which also has pubescent leaves, it differs chiefly in its spreading and pilose, not velutinous pubescence, more deeply lobed smaller leaves, shorter petioles, the calyx-tube not silky outside and in the glabrous ovary.

Securinega suffruticosa (Pall.) comb. nov.

Chenopodium ? suffruticosum Pallas, Reise Russ. Reich. III. pt. 1, p. 424 (1776), nomen.

Pharnaceum ? suffruticosum Pallas, op. cit. III. pt. 2, p. 716, t. E, fig. 2 (1776).

Xylophylla ramiflora Aiton, Hort. Kew. I. 376 (1789).

Osyris alba Georgi, Beschr. Russ. Reich. III. 1341 (1800); non Linnaeus (ex Ledebour, Fl. Ross. III. 583).

Phyllanthus ramiflorus Persoon, Syn. Pl. II. 591 (1807).

Geblera suffruticosa Fischer & Meyer in Index Sem. Hort. Petrop. I. 28 (1835).—Ledebour, Fl. Ross. III. 583 (1851).

Flüggea suffruticosa Baillon, Étud. Gén. Euphorb. 592 (1858).

Phyllanthus fluggeoides Mueller Arg. in Linnaea, XXXII. 16 (1863).

Phyllanthus japonicus Mueller Arg. in Linnaea, XXXII. 52 (1863), in part.

Securinega ramiflora Mueller Arg. in De Candolle, Prodr. XV. pt. I. 449 (1866).—Rehder in Jour. Arnold Arb. VII. 191 (1926); VIII. 152 (1927).

Securinega fluggeoides Mueller Arg. in De Candolle, Prodr. XV. pt. I. 450 (1866).

Securinega japonica Miquel in Ann. Mus. Bot. Lugd.-Bat. III. 128 (Prol. Fl. Jap. 292) (1867), in part.

Some time ago Mr. H. C. Skeels drew my attention to the fact that *Securinega ramiflora* (Ait.) Muell. Arg. had an older specific epithet, namely "suffruticosa" going back to *Pharnaceum ? suffruticosum* Pall. of 1776. Fischer and Meyer based the type of their new monotypic genus *Geblera* on *Pharnaceum ? suffruticosum*, of which Pallas gives not only a fairly accurate, though incomplete description but also a figure of a flowering branch; this figure with the description, taking into consideration the region where the plant was collected, shows clearly that the plant described by Pallas is identical with *Securinega ramiflora*.

I am unable to find specific differences between *S. ramiflora* and *S. fluggeoides*, as I have already stated in this Journal (VII. 191 and VIII. 152); all the differences given are variable and do not hold in the numerous specimens before me. Also *Securinega japonica* Miquel, at least partly, belongs here, excluding the name bringing synonym, the specific epithet having been taken from *Hemicicca japonica* Baill. which is a synonym of *Phyllanthus flexuosus* (Sieb. & Zucc.) Muell. Arg.

Vitis Wilsonae Veitch apud Gard. Chron. ser. 3, XLVI. 236, fig. 101 (1909), nomen seminud.—Rehder in Sargent, Pl. Wilson. III. 428 (1917), pro synon. *V. reticulatae* Gagnep.

Vitis reticulata Pampanini in Nuov. Giorn. Bot. Ital. XVII. 429, fig. 13 (1910).—Rehder, Man. Cult. Trees Shrubs, 603 (1927).—Non *V. reticulata* (Thwaites) M. A. Lawson.

Vitis reticulata Gagnepain in Lecomte, Not. Syst. II. 12 (1911); in Sargent, Pl. Wilson. I. 103 (1911).—Non *V. reticulata* (Thwaites) M. A. Lawson.

This species was described at approximately the same time independently under the same name by Pampanini and by Gagnepain, but based in each case on different specimens; by Pampanini on Silvestri, no. 1438 and by Gagnepain on Farges, nos. 539 and 124 and on Wilson, Veitch. Exp. no. 1151. Both authors overlooked or disregarded the older homonym *Vitis reticulata* M. A. Lawson which they probably considered as based on the invalid name *Cissus reticulata* Thwaites, changed by Planchon to *Cissus retivenia* on account of the earlier *C. reticulata* Bl., which was cited by Miquel (in Ann. Mus. Bot. Lugd.-Bat. I. 81. 1863) only as a synonym of *Vitis geniculata* (Bl.) Miq. and did not become a valid name until Planchon published a description in 1887. There exists, however, a still earlier name, *C. reticulata* Willd. apud Roemer & Schultes, Syst. III. Mant. 248 (1827), which was referred to *Cissus canescens* Lam. by Kunth. *Vitis Wilsonae*, the earliest name given to this species, was not taken up, as it was considered a nomen nudum or seminudum having been published with an insufficient description and a figure of a leaf. It was identified with *V. reticulata* Gagnepain in 1917 and is now the only available name for this species.

Acanthopanax stenophyllus Harms f. **dilatatus**, f. nov.

A typo recedit foliolis semper 3 (in specimine viso tandem) oblongo-oblanceolatis vel oblongo-obovatis petiolulo brevi incluso 6–11 cm. longis et 2–3.5 cm. latis.—Frutex inermis, glaber, ramulis brunneis levibus.

CHINA. Shansi: Yuan-ch'ii distr., Shui-wang-ping, in silva subalpina, alt. 1900 m., *Harry Smith*, no. 6563, July 21, 1924.

This plant is apparently an extremely broad-leaved form of *A. stenophyllus*, though at first glance it looks very distinct on account of its much broader leaflets, and particularly if compared with the other extreme of the species, *A. stenophyllus* f. *angustissimus* Rehd. (in Jour. Arnold Arb. IX. 99. 1928) with leaflets only 3–5 mm. wide. It seems hardly possible that these two extreme forms could belong to one species but I can find no other character to distinguish it from *A. stenophyllus*. From *A. Wilsonii* Harms, with which this form also may be compared, it differs in its much larger and thinner leaflets, the middle one distinctly stalked and in longer pedicels.

Campsis Tagliabuana (Vis.), comb. nov. (= **C. chinensis** × **radicans**).

Tecoma Tagliabuana Visiani in Atti Istit. Venet. Sci. ser. 3, IV. 135 (1859).—Meunissier in Rev. Hort. 1928, p. 310, tab.

Tecoma hybrida hort. ex Dippel Handb. Laubholzk. I. 48 (1889), pro syn. *T. grandiflorae*.—Jouin in Jardin, XIII. 104, tab. (1899); Garden LV. 315 (1899).—Rehder in Sargent, Trees & Shrubs, I. 93, t. 47 (1903).

Campsis hybrida Zabel in Ruempler, Gartenb.-Lex. 166 (1901).—Rehder in Bailey, Stand. Cycl. Hort. II. 652 (1914); Man. Trees Shrubs, 790 (1927).

Tecoma intermedia Schelle in Beissner, Schelle & Zabel, Handb. Laubholz-Ben. 435 (1903).

It seems strange that Visiani's name *Tecoma Tagliabuana* which was published with a full Latin description and the definite statement that it is a hybrid between *T. radicans* and *T. grandiflora*, has been completely overlooked by all the later authors and no mention of this name is found in botanical or horticultural literature, until Meunissier resuscitated it in an article in Revue Horticole in which he gave complete data and a colored plate of this hybrid. According to Visiani the hybrid was raised by the brothers Tagliabue apparently some time before 1859, but it does not seem to have been distributed under Visiani's name. The hybrid, however, has appeared in gardens under various other names. The first references I find are those given in 1872 by K. Koch (Dendrol. II. 308) as *T. Princei coccinea grandiflora* and in 1877 by Lavallé (Arb. Segrez. 176) as *T. radicans coccinea grandiflora*.

It is also probable that *T. radicans atropurpurea* mentioned in 1865 by Jaeger (Ziergehölze, 134) represents this hybrid; at least specimens I have seen under the name *T. atropurpurea* and *T. grandiflora atropurpurea* belong to it. Also the following names are referable to forms of this hybrid: *Tecoma grandiflora aurantia* and *T. grandiflora Princei* (Dippel, Handb. Laubholzk. I. 48. 1889); *T. chinensis aurantiaca* (Koehne, Dendr. 522. 1893); *Campsis radicans* f. *atropurpurea* Voss, *C. chinensis* f. *aurantiaca* Voss and f. *Princei* Voss (Siebert & Voss, Vilmorin's Blumengärt. I. 801. 1894); *T. radicans Princei*, *T. grandiflora rubra* Hort. Sahut and *T. grandiflora Madame Galen* Hort. Sahut (Nicholson & Mottet, Dict. Hort. Prat V. 208, 209. 1898); *T. radicans grandiflora atropurpurea* and *T. Princei coccinea grandiflora* (Jouin in Jardin, XIII. 104. 1899); the same specific and varietal names may appear in horticultural literature or in catalogues under *Bignonia* or under *Campsis* instead of *Tecoma*.

Lasianthus Labordei (Lévl.), comb. nov.

Canthium Labordei Léveillé in Fedde, Rep. Spec. Nov. XIII. 178 (1914); Fl. Kouy-Tchéou, 364 (1915).

CHINA. Kweichou: district de Tsin-gay, mont de Kao tchay,

penchant escarpe des montagnes, *J. Laborde & E. Bodinier*, no. 2109, March 7, 1898 (holotype of *Canthium Labordei* in Herb. Edinb.; photo. in Herb. Arnold Arb.); Si-mi-yao, Pa-na, Cheng-feng hsien, *Y. Tsiang*, no. 4423, Oct. 25, 1930 (low shrub in dense shade); foot of Van-ching-shan, Kiang-kow, alt. 450 m., *Y. Tsiang*, no. 7487, Dec. 8, 1930 (small tree in light wood); foot of Van-ching-shan, Yin-kiang, alt. 500 m., *Y. Tsiang*, no. 7591, Dec. 12, 1930 (low shrub, 0.30 m.); border of Ksi, Tan-ling, Tuh-shan, S. Kweichou, alt. 500 m., *Y. Tsiang*, nos. 6951 and 6956, Sept. 7, 1930 (shrub, 1 m., in dense shade).

This specimen described by Léveillé as a *Canthium*, a genus referred by K. Schumann as a section to *Plectronia*, does not belong to that genus, as the usually 4-seeded fruit and the style divided at the apex into 4 linear stigmas clearly show. It apparently is referable to *Lasianthus* and seems most closely related to *L. longicauda* Hook. f., from which it differs chiefly in its much narrower leaves 5–14 cm. long and usually 8–16 mm. broad, with less prominent veins and obsolete veinlets and in the glabrous or nearly glabrous pedicels; the whole plant is generally quite glabrous, only on no. 6956 a slight pubescence is noticeable on the tips of the branchlets, the upper petioles and on the very young calyces. No. 7487 differs in its somewhat broader leaves being about 7 cm. long and 1.8 cm. broad, while no. 7591 differs in the leaves being rounded at the base and borne on very short petioles about 1 mm. long.

Of *Lasianthus longicauda* Hook. f. I have seen no Indian material, but two Yunnan specimens (Henry nos. 9035 and 10633) determined by Hutchinson and one Yunnan specimen collected by Delavay at Long-ki and determined by Pitard as *L. japonicus* Miq. which doubtless belongs to *L. longicauda* and not to *L. japonica* Miq. from which it differs in the quite glabrous more caudate leaves, the nearly glabrous branchlets, less pubescent calyx and in the corolla-lobes being glabrous inside except at the base, while in *L. japonica* according to Yatabe's figure (Iconog. Fl. Jap. 1. t. 28) the corolla-lobes are densely villous inside to their very tips.

(*To be continued*)

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THE CRATAEGUS PROBLEM

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IN LOOKING OVER the field of American taxonomic botany, as judged by the manuals, reports, and local plant lists that have been published since the beginning of the present century, it must be apparent to any one that the biggest unsolved problem and the one about which the greatest difference of opinion exists is that of the genus *Crataegus*, especially as regards the validity of the large number of species that were proposed, mostly during the first decade of the century.

There can be little wonder that when the twenty or twenty-five supposedly well-known species of the older manuals began to expand by scores and hundreds, until more than a thousand new species and varieties had been published, the first feeling of surprise on the part of the general students of botany and interested laymen, later assumed something like an attitude of dismay and incredulity, as they realized the hopelessness of attempting to become acquainted with or to identify living plants and collections of this genus from technical descriptions, in many of which only very slight characters were indicated to differentiate the proposed species.

In Gray's Field, Forest and Garden Botany, published in 1857, twelve species and two varieties of *Crataegus* were listed for the states east of the Mississippi River. This included native and cultivated Thorns. Ten species and four varieties, native and introduced, were recognized in Gray's Manual of Botany, that appeared in 1867. In 1860 Chapman published his Flora of the Southern United States, in which descriptions were given of eleven species and one variety, most of them being the species of Gray's Manual, with only three additions. Four species were mentioned in Coulter's Manual of Rocky Mountain Botany, in 1885. Three years later Focke, in Engler and Prantl, estimated that there were about 30 or 40 species of the genus growing in the North Temperate Zone. The Sixth edition of Gray's Manual, the last to appear in the 19th century, was published in 1889, and in this work only ten species and four varieties of *Crataegus* were recognized for the Manual range.

Up to the year 1899 about 175 names, including varieties and forms, a number of them merely on garden lists and without botanical descriptions, had been published for North American

Crataegi. A large proportion of these were segregates of supposedly polymorphic species, such as *C. crus-galli*, *C. coccinea*, *C. punctata*, *C. glandulosa*, *C. tomentosa*, and others.

About ten years later what may be called the period of expansion for the genus began. In 1899 and 1900 Beadle and Ashe published independently descriptions of several new species from the southeastern United States, followed quickly by many others, and Sargent a year or two later began describing many new forms, mostly found in the Northeastern and Central States. Altogether Mr. Ashe has published at least 177 species and 3 varieties of *Crataegus*, Mr. C. D. Beadle 143 species and 1 variety, and Professor Sargent more than 700 species, 22 varieties and 5 forms. A small number of Sargent's names were new combinations or were proposed as substitutes for various reasons for his own previously published species or for those of others.

The treatments of the genus that have appeared in the manuals and local floras since this period of expansion began have all been admittedly provisional and partial, with frequent shifting of ground in regard to the species recognized and the passing over entirely of many others. This is not surprising nor a matter for adverse criticism, but it serves to illustrate the difficulty of the problem.

Most compilers of local lists have in the meantime given up entirely any attempt to enumerate the Thorns of their regions, and have simply mentioned the fact that various unrecognizable species occur; some have referred their readers to the manuals or other general treatments, or have submitted collections to a few institutions or students of the genus who were willing, or who had the temerity, to undertake identifying them. The Arnold Arboretum has been called upon to pass upon a number of such collections, and in spite of the large number of types and the great amount of other material in the herbarium, as well as an extensive collection of living plants and ample literature available here, it has in many cases been a difficult matter to make determinations of some of the specimens, even when flowers or fruit were present, and in most cases it is quite out of the question to determine them from sterile specimens or from a single leaf or flower, as can often be done in such groups as the Willows, Oaks, Maples, Roses, and many others.

As a result of this situation a feeling seems to have arisen among many unprofessional and uncritical students of plant life, and even amongst some botanists, especially those not mainly concerned with taxonomy, that a hopeless confusion exists in this genus and that most if not all of the recently proposed species are

without standing and should be disregarded. It has also been suggested that the genus is in a state of mutation or instability or that the different forms have been so frequently hybridized with each other that no clear specific lines can be drawn as in other genera, and that almost any individual tree might be made the type of another so-called species.

Such a situation as the present is obviously unsatisfactory and unscientific, but much of the uncertainty and skepticism, understandable as it is, does not seem to be entirely warranted by the facts. For it is probably true that morphological characters peculiar to and inheritable in segregable groups of individuals that we call species are generally as constant and well marked in this genus as in many other genera of the *Rosaceae* or other families, such as *Rubus*, *Rosa*, *Prunus*, *Cotoneaster*, or *Rhododendron*. The main difference and difficulty in regard to *Crataegus* as contrasted with such other genera is that of size, the very large number of species that must be dealt with in any adequate general treatment, their wide geographical range, and the practical difficulties of studying or collecting them in the field, with the uncertainties of seasons and irregularity of fruit crop, or of bringing together under cultivation a collection at all adequate for a general revision. But in addition to this it will be generally agreed, I believe, that matters have been greatly complicated by the way in which the genus has been treated in the past in botanical literature, many of the older names having been published without recognizable descriptions or definite data as to where the plants to which they applied originated. And in regard to the much larger number of species that were distinguished later, although these were generally accompanied by fuller descriptions, much uncertainty exists because they were in many cases based upon very slight differences separating them from others, and perhaps sometimes without sufficient field study to determine the constancy of their distinctive characters, or without sufficiently careful comparison with previously described species to which the material might have been referred with a broader conception of species, under which plants with slight but evident distinctive characters might have been treated as varieties or forms of the more outstanding species.

It has long seemed to the writer that, for practical reasons, such a conservative treatment, in dealing with as large a genus as *Crataegus*, is most desirable, and studies with this in view both in the field and at the Arnold Arboretum have been in progress for several years.

In view of the great amount of work done upon the genus by

the late Professor Sargent and the accumulation of material and literature in the herbarium, plantations, and library here, it seemed evident that the Arnold Arboretum was the logical place for initiating and carrying out such a work, and indeed, that it could scarcely be done with adequate facilities anywhere else. And for this reason, after being urged to do so from a number of sources, the writer rather reluctantly undertook this difficult and somewhat formidable task.

The collection of *Crataegus* in the herbarium here is without doubt the largest and most complete in existence, and although it, naturally, does not contain specimens of all the forms of Thorns that have been described, the approximately 25,000 sheets from all parts of North America, including all of the type material of the species described by Sargent as well as isotypes of many others, have been assembled to represent as fully as possible the geographic range as well as the morphological characters and the behavior under cultivation of as many species as were obtainable.

At the beginning of Professor Sargent's intensive study of *Crataegus* he initiated the plan of planting seeds from the type tree, and from other specimens, of each of his newly described species, as well as of those previously known, and of many others from which herbarium material had been collected but which had not yet been determined. This plan has been continued, and in the thirty years that have elapsed since its beginning the plantation has grown into a collection at the present time of about 1,400 labelled trees of record, representing nearly 700 species and varieties, only a small percentage of which are of Old World origin. Other species that were grown, many of them to maturity, are no longer living, but herbarium specimens of them have in most cases been preserved. The plantation on Peters Hill at the Arboretum is now probably the largest living collection of any single genus of woody plants, or at least of trees, that has ever been brought together for the purpose of scientific study.

A critical study of the trees of this collection and a comparison of them with the herbarium specimens and record of the native parent plants from which the seed was taken has been in progress for several seasons, and it is expected to throw valuable light upon the status and relationship of many species. With this evidence it will be possible for the first time to determine in many cases whether the distinctions upon which the described species were based are constant or are merely individual variations, as well as to arrive at more definite conclusions as to the relative value of such characters as pubescense, the number of stamens and styles,

color of the anthers, shape and color of the mature fruit, &c., as specific criteria.

To examine and make notes upon this large number of trees both in the flowering and fruiting stage and to make the necessary comparisons with the herbarium material and with the published descriptions, is at best a slow process and one attended with some practical difficulties. Most of the trees have now grown to fruiting size but not all of them produce flowers or fruit each year, some seasons being quite unfavorable to the less hardy forms. Others are just coming to maturity and some flower for the first time each year. Since the flowers are very transient and it is possible to determine the color of the anthers for only a short period after they open, the season often advances so rapidly that it is difficult to keep up with them in this stage. Additional field work which is urgently needed in this genus in many parts of the range also presses at this season and for several years it has made it impossible for me to be at the Arboretum in spring.

It should also be understood that large as the collection here is, and furnishing as it does by far the best experimental data so far available, it is by no means complete or fully adequate for a study of the whole genus. Some species of the southern states have not proved hardy in this climate and for various reasons many which have been started have not survived and others have not been secured. It can easily be understood that a certain amount of error was almost unavoidable in the various steps from collecting herbarium specimens and seeds in the field, planting and germinating these, transplanting the seedlings to nursery rows, and finally to a permanent place in the collection, as well as later in keeping records and in having the plants properly labeled. A small percentage of such errors have been detected in the collection here. Some of these are so obvious as to be unmistakable and sometimes correctable, but in a few cases they may leave open to doubt questions of possible variability, which we would like to settle. In addition to this the first idea of the plantation, which seems to have been merely to illustrate the different species by typical specimens, was scarcely broad enough to furnish conclusive evidence such as might be desired to decide in some doubtful cases. It was of course impractical to attempt to grow a large number of each of the several hundred supposed species to fruiting size, but it would have been most helpful if this had been done in a few selected cases at least.

The main region of distribution for *Crataegus* in North America extends from the Atlantic seaboard to beyond the Mississippi

river, and the border of the plains. The western boundary may be roughly taken as running from northwestern Minnesota, through eastern Nebraska, Kansas, and Oklahoma, to the mouth of the Colorado river in Texas. Many of the species and several of the groups disappear much farther east, and several sub-regions may be recognized. West of this region *Crataegus* is a genus of minor importance and such scattered species as occur are mostly quite different and distinct from those of the east, and the problem is comparatively simple. Some of the western species are associated with the Sonoran floras and range southward into Mexico, and others belong to the Rocky Mountains and Pacific floras.

A considerable part of this main area has been pretty thoroughly explored, but it should be remembered that there are still large sections of the country in which very little collecting has been done and where the Crataegus flora is still inadequately known.

Most of the material studied by Sargent and other recent authors was brought together as a result of intensive collecting by local students in a comparatively few limited areas. A large amount of material was left undetermined in the herbarium here, and while much of this has recently been placed with described species, a number of collections remain, with either complete or partial material, that cannot be so disposed of, and reluctant as one might be to add to the number already published, it will be necessary to describe some of these that seem clearly distinct.

The sections of North America where the Crataegus flora is best known and from which material is fairly adequate are the St. Lawrence valley, most of New England, New York, Pennsylvania, and parts of the Southeastern and Middle-western States and the Rocky Mountain and Pacific States. Additional field work is particularly needed in parts of Ohio, Michigan, Wisconsin, Minnesota, Iowa, Arkansas, Tennessee, Oklahoma and eastern Texas, as well as in the Piedmont regions of the Gulf States. But while there is every reason to believe that some new species and varieties will turn up in these regions, it is not likely that the number that cannot be referred to forms already known will be large.

There are doubtless many questions in regard to the genetic relationships and the ideal classification of *Crataegus*, as in other plant groups, that cannot be definitely settled on purely morphological grounds. Experimental growing of seedlings on a large scale, cross-breeding, and cytological study of the chromosomes, as well as of the physiology, histology and pathological responses of the supposed species will ultimately throw much light upon some of these, and may greatly modify our present systems of classi-

fication and conception of species. Investigations along some of these lines are now in progress at the Arnold Arboretum and elsewhere, but the practical difficulty of applying such tests to hundreds of forms of such slow-growing plants as *Crataegus* is obvious. According to Mr. W. H. Judd, propogator for the Arboretum, the seeds require from two to six years to germinate. And on an average ten years more must elapse before they grow to fruiting size.

But valuable as such investigations are, they have not yet progressed far enough, at least in the case of *Crataegus*, to be used as the basis for any scheme of classification. And indeed it scarcely seems likely that they can ever be so used except in a limited way, or that any classification based mainly upon other than obvious morphological characters can be devised that will be practicable and usable by the large and increasing number of people of all degrees of scientific attainment who are for various reasons interested in the study of plants. Of course a taxonomic arrangement based upon morphological characters should, approximately follow lines of genetic relationship, but in certain cases it probably does not do so consistently, and as in keys used in the manuals to aid in locating species, an artificial arrangement is sometimes more useful and usable than one that is concerned only with natural relationship.

In considering any scheme of classification it is well to understand clearly what the writer means by the term species or other subdivisions of the group, for there is still nothing like uniformity in the use of such terms. If we begin by recognizing that there is nothing inviolable or sacrosanct about a species, but that it is merely a convenient unit to be employed in describing a group of plants or animals having a number of recognizable characters in common, and that the limits of such a unit must be based upon the best judgment of some competent observer who has studied the group, it is evident that a considerable degree of latitude may be exercised in the use of the term. The number of species in any group will therefore vary according to whether the author takes a narrow or a broad view of the species. The decision must be more or less arbitrary, and naturally there will be room for differences of opinion about any proposed classification, and in the nature of things it must be somewhat provisional and subject to revision. It might be more accurate to refer to such units as morphological species, since they may differ greatly in limits and numbers from the species concept of the geneticist or cytologist.

A system of classification in which only species are recognized, and

one in which consequently only Linnaean binomials need be employed, has its obvious advantages in simplicity, especially in small groups. But to attempt to treat such a large genus as *Crataegus* in this manner would result either in an enormous and unwieldy number of species, or specific lines would have to be drawn so broadly and with so many exceptions as to make them almost useless. A conservative treatment, such as seems desirable here, should regard as species all readily recognizable forms that can be distinguished by a group of characters or at least by more than one clear difference, with descriptions broad enough to allow for a reasonable amount of individual variation, to be determined by observation. Under varieties would be placed such subdivisions of the species as differ from the typical form of the description in a single clearly recognizable character or in one or more minor details. And in some cases it might be desirable to give names to forms in which a single distinguishing character less clear or constant is found.

Under such a treatment the number of species might be considerably reduced from the present total, but it would still be large, probably much larger than in any other genus of woody plants in the American flora, unless we refuse arbitrarily to recognize as species forms quite as well marked as many of those generally so treated in other genera. Such a course would go far towards defeating its own purpose.

Although no satisfactory general treatment of *Crataegus* has yet appeared since the publication of the large number of recently proposed species, some progress has been made towards a better understanding of the genus. New combinations have been made by Mr. Eggleston and others reducing a large number of species to varietal rank, and many others have been treated as synonyms. In many cases the view taken is probably correct and constitutes a real contribution, but in regard to others there seems to be very good ground for maintaining them as species, based upon our observations here. This is quite understandable, since it is not likely that any two students working critically on so large a group could agree in all cases. It must also be admitted that some provisional treatment short of recognizing all of the hundreds of newly described species was urgently needed for the general manuals, and that on the whole the space given in them to this genus was as large as could have been expected. Still it is not possible to limit the number of species in a genus by law or rule, desirable as this might be in some respects. And we, therefore, have felt here that it will be better to proceed slowly and to collect as much data as possible before attempting a revision.

Sufficient progress has been made in observing the living collections at the Arboretum, in additional field work and in rearranging and critically studying the material in the herbarium, to make it possible to draw a few general conclusions.

The extreme complexity of the genus, the existence of many distinct forms in all parts of North America, many of them being quite local in range, and which were unrecognized and unaccounted for in the older manuals and floras, has been amply demonstrated. The recognition of this fact and the great amount of work done in making them available for study both through published descriptions and cultivation constitutes a great contribution on the part of Sargent and his co-workers and contemporaries. It cannot be too strongly emphasized that nearly all of the large number of forms described were based upon real differences. Whether these differences were sufficient to be made the basis for specific distinctions is an open question about which there can properly be much difference of opinion. In the opinion of the writer it might have been better in many cases to have treated them as varieties or forms or merely as variations of polymorphic species.

The specimens cultivated at the Arnold Arboretum show generally that the distinctive characters of the wild specimens, which were taken as the basis for the new species hold true often to the minutest particular. There are a few exceptions to this.

Besides the plantations at the Arnold Arboretum a very large number of species were grown and records kept of them by the Park Department of Rochester, New York. The collection there is available for study, and those who have been in charge of it report similar results, and indeed some of them are much more inclined to recognize and to insist upon the distinctiveness of the species than we are.

In addition to those species that can probably be more properly treated as forms or varieties, some others were published of which the names were invalid, or which cannot be maintained for various reasons. In some cases names were preoccupied or the same name was used more than once for different species by the same or by different authors. Most of these cases have already been corrected but apparently a few still remain. Duplicate descriptions undoubtedly sometimes appeared of the same plants, either by the same or by different authors working independently. This was almost unavoidable from the mass of material that was being handled, the rapidity with which the descriptions appeared, and the small amount of tabulation that had been done, as well as because the characters of some of the sections into which it has been proposed to divide the genus were not properly understood.

There is a very wide range in the variability of the leaves, flowers, fruit and several others characters in *Crataegus*, and the species can be arranged in several natural sections or groups. There have been a number of attempts at dividing the genus into these sections, with considerable variation as to the number, arrangement and limits of the groups. The oldest arrangement is that of Loudon in 1838.[1] In this treatment, he arranged the species of which he gave description in 15 sections, of which one (XV. *Pyracantha*) is not now included in the genus. Four others, his sections *V. Nigrae*, X. *Azaroli*, XI. *Heterophyllae*, and XII. *Oxyacanthae*, are exclusively Old World groups. His other sections are clearly recognizable and most of the names are retained, with a few changes in the placing of species. The sections of American Thorns were I. *Coccineae*, II. *Punctatae*, III. *Macracanthae*, IV. *Crus-galli*, VI. *Douglasii*, VII. *Flavae*, VIII. *Apiifoliae*, IX. *Microcarpae*, XIII. *Parvifoliae*, and XIV. *Mexicanae*. To these a number of new sections have been added by later authors.

Mr. Eggleston in his treatment of the genus in the 7th edition of Gray's Manual (1907) arranged the American species that came within the geographical range of that work into 17 sections, and in the 2nd edition of Britton & Brown, Illustrated Flora (1913) he has 15 sections, some of them slightly changed in scope from the former treatment.

Professor Sargent proposed several new sections, and in his last treatment, in the 2nd edition of the Manual of the Trees of North America (1922) he arranged the arborescent species into 20 natural groups, which did not take into account the Mexican species nor the two exclusively shrubby groups, *Parvifoliae* (*Uniflorae*) and *Triflorae*. In the course of his studies of the genus he abandoned his groups *Lobulatae* and *Flabellatae* and seems to have changed his view regarding the groups *Coccineae* and *Rotundifoliae*, as well as to have accepted Beadle's name *Silvicolae* as having priority over his *Medioximae*, and *Macracanthae* of Loudon for *Tomentosae*.

Mr. Beadle, in his generally excellent treatment of the species of the southeastern United States, as it appears in the 2nd edition of Small's Flora, has carried the division of the genus into sections to an extreme degree, basing some of them, as it seems to me, upon characters of no more than specific value, and in the case of the *Crus-galli* and *Berberifoliae* scarcely that in some cases. Thirty-three sections are recognized in this work, which covers less than a third of the area of the United States.

The sections differ considerably from each other in their dis-

[1] Loudon, J. C. Arboretum et fruticetum britannicum, II. 813–867 (1838).

tinctiveness and in the constancy of the characters by which they can be recognized. It is generally possible to definitely place most species in the proper group with the help of keys or by one familiar with them, but in most cases there is an indistinct border line where one group merges into another, and perhaps into more than one in different directions or in different areas, and it is difficult to say whether certain species belong with one or with the other. This may indicate either hybrids between species of the different groups, which is sometimes probably the true explanation, or it may indicate merely the relationship of the groups to each other and that certain intermediate species connect them. For example, in the section *Crus-galli*, which is generally one of the best marked of the larger groups, some species approach in the character of their fruit and foliage those of the section *Punctatae*, which is usually placed next to it, and in other species, the thinner or slightly lobed leaves and smaller fruit, which may finally become mellow or succulent, or in the thinner, scaly, bark of the trees, an approach to the *Virides* is found. The *Virides* group has good distinguishing characters in most cases, but besides certain species that seem in some ways intermediate with the two previously mentioned, some of the species assigned to the *Pulcherrimae* in the southeastern states have certain resemblances to this section, and in southeastern Texas species have been found that seem intermediate between *Molles* and *Virides*. There has been much uncertainty about the *Coccineae* group. Loudon obviously intended to take *Crataegus coccinea* L. as the type of this. The illustration he gives for the typical form of that species suggests some large-leaved form of such a species as Sargent's *Crataegus pedicellata*, but the description he gives seems to have been drawn from several forms that have later been considered as distinct, probably including *C. mollis*. It also is difficult and perhaps impossible to tell what Linnaeus' species was, as that too appears to have included two or more distinct things. It is not an unnatural consequence that later authors have been much confused and very hazy in the interpretation of this species, and indeed it has since been made to include either typically or as varieties, forms of many diverse species of American thorns. The group *Coccineae*, as finally used by Sargent, includes several species of the northeastern United States and Canada, having rather large, thin leaves, mostly glabrous when mature, flowers in which the styles are usually less than five, and fruit with rather small, sessile calyx, and flesh that becomes pulpy or succulent at maturity. On the one side this group approaches the *Tenuifoliae* and on the other the *Molles*, and although,

as in other cases, it is difficult to decide definitely to which of these groups certain species belong, a description broad enough to cover such a wide diversity of forms as have been included under this group and the *Molles*, as well as those of the small *Dilatatae* group of Sargent, would lose much of its taxonomic value.

The same situation seems to obtain with most of the other groups, which it is not necessary to take up in detail here. Attention may be called, however, to the fact that there are several small groups, such as *Aestivales*, *Brachyacanthae* (*Brevispinae*), *Microcarpae* and *Cordatae*, which appear to be so clearly distinct that they probably represent species that originated quite early in the history of the genus.

It seems probable that *Crataegus* was a comparatively early offshoot from the *Pomaceae* stock, but that its principal development has taken place since the Glacial periods of the Quaternary and even in very recent times. It may have originated at rather high latitudes in Eurasia in a period of favorable climatic conditions and been dispersed from a circumpolar center southward into both hemispheres before the close of the Tertiary era. This view seems to be supported by its present wide distribution and that of associated plants, and by the fact that the genera most closely related to it amongst living plants, such as *Osteomeles*, *Cotoneaster*, *Pyracantha* and *Mespilus*, are confined to the Old World. That the groups found in the two hemispheres are all, or nearly all, quite distinct would also indicate a considerable period of isolation.

Paleontological evidence seems to be rather meager for a genus so abundant and widely distributed at present, but a number of fossil species have been described, based upon either leaves or fruit, from both the Old and New World. A comparison of these with living species will be of value and may throw light upon the present distribution and relationship of the different groups.

A few generalizations can be made as to the geographic distribution of the groups and some of the species in America, and its significance.

A large proportion of the species that have been described appear to be quite local and in not a few cases the only material known is that from the type locality or from a single tree. Such species, when they come from regions that have been pretty well explored botanically, naturally fall under suspicion as to their validity, and many of them will probably prove to be only divergent forms or hybrids. Many species, however, and some of them well marked ones, are of quite restricted range. This may be accounted for in two ways: either they are comparatively recent forms that have

not been able to spread far from the point of origin, or they may be relics of ancient and disappearing types. In the case of *Crataegus* the former seems much the more probable explanation. Several considerations lead to this conclusion, but it need only be mentioned here that in the case of relic species the range is usually interrupted and they crop out in peculiarly protected or favorable spots, often widely separated from each other. This is not the case in *Crataegus*, with a very few exceptions, so far as known.

Most species of *Crataegus* are more or less pronounced calciphiles, and they are found in the greatest diversity and abundance in limestone regions. Many of them are limited to such outcrops, and the soil factor is probably an important one in determining their distribution. There are, however, some striking exceptions to this. There is a marked zoning of the groups from north to south, and to the westward they are limited by aridity, like other mesophytic plants, as they approach the plains. But there are various other minor causes, besides soil and climate that serve to limit them and that have brought about the present distribution. This is emphasized by the fact that in spite of the limits of the groups north and south in nature, the species in the main seem quite adaptable in the matter of climate, many of those native to Florida and southern Texas having proven hardy in New England.

The genus as a whole is not adapted to spreading in forest areas, and most species are essentially plants of prairie openings, borders of woods, copses, pastures and glades, or along the open banks and bluffs of streams. In primitive times such habitats in Eastern North America, where other conditions were favorable, were not of wide extent. The great unbroken forest that extended from the Atlantic coast, across the Mississippi valley, to the edge of the plains, afforded only occasional opportunities for the growth of such small trees and shrubs, and in places where they might seek to gain a foot-hold they were probably held in check by frequent fires and by grazing animals, since the young shoots, before the spines are sufficiently developed to afford protection, are eagerly eaten by the ruminants. The seeds are heavy and are not likely to be transported far except when carried by water or in the stomachs of birds and other animals. The latter seems to be an important means for their dissemination at present, but so long as favorable localities were lacking this would avail little, and their advance was also probably impeded by the slow germination of the seeds.

Since the clearing away of the forest on such a large scale, vastly greater areas have become available and there has undoubtedly

been a great increase in their development and in the spread of species in recent years.

The distinct calciphiles and rock growing species, or those of more specialized requirements, are usually the most limited in their range, and the more widely distributed ones, such as *Crataegus crus-galli*, *C. punctata*, *C. viridis*, *C. apiifolia*, *C. spathulata*, *C. Margaretta*, and *C. tomentosa*, are such as grow in alluvial ground or that follow the courses of large drainage basins.

In general it may be thought that the more widely distributed species are the ancient ones, or that at least they are not of very recent origin. The criterion of age and origin is probably, however, only partly reliable in this genus, since other factors, as pointed out, have served to aid or retard their extension. In the writer's opinion the groups *Aestivales*, *Brachyacanthae* and *Mexicanae* are probably most closely related amongst American Thorns to the primitive types, and none of these have a particularly wide geographical range. In the case of *Aestivales*, at least, this may be due to the peculiar and limited habitat. And it is probable that all of them are retreating or disappearing groups.

A striking exception to the usual soil preference and habitat of most of the groups is afforded by the large association of forms which has been classed under *Flavae*, although Mr. Beadle divides them into twelve or fourteen sections, of which it may be desirable to maintain some. These are restricted to the southeastern United States, where they are very abundant, and they are for the most part decidedly oxylophiles, inhabiting dry, sandy, upland woods, or areas occupied also by a peculiar stunted shrubby flora, known as "scrub" in Florida, where the soil is a deep fine deposit of nearly pure sand. Typical trees of this group have quite a distinctive habit of growth. The older trunks are clothed with a thick dark bark which is deeply fissured and cross-checked into small blocks, much as in *Cornus florida*, *Diospyros virginiana* or *Viburnum rufidulum*. The stiff, curved, branches are usually terminated by slender branchlets, which are either zig-zag or pendulous, and thickly set with single or small clusters of flowers and the foliage and inflorescense is extremely glandular. Other exclusively southern groups are the *Pulcherrimae*, *Triflorae* (*Bracteatae*), *Microcarpae*, *Brachyacanthae*, and *Aestivales*.

Uncertainty concerning the characters and limits of some of the groups, and the actual difficulty of determining to which group certain species belong seems to have been the cause of some confusion in the past and may have been responsible in some cases for the duplication of descriptions of identical plants, which can

be properly placed when brought into comparison with each other.

How far the matter of hybridization enters into the problem of the complexity and proper classification of *Crataegus* is a puzzling one, and one that cannot be settled definitely without a great deal more experimental work being carried on systematically through many years.

From what is known of the rather frequent cases of hybridization amongst other Rosaceous genera, and from the fact that several supposed hybrid species of *Crataegus*, as well as a cross with the closely related genus *Mespilus*, are in cultivation, and others are found growing spontaneously that suggest such an origin, it is almost impossible not to believe that natural hybrids do sometimes occur. Anyone who has been in a large growth of *Crataegus* in early summer, where many diverse forms are growing together, and several of them blooming simultaneously, with the wind carrying pollen, and with swarms of busy insects flitting from one flower and tree to another, can easily see how this might come about.

At the same time it must be remembered that there are many ways in which the integrity of species is protected in nature, and if this were not so, the numerous distinct forms that are found in many large genera could never have been segregated or maintained. Slight physiological differences are often enough to insure immunity, and in the case of *Crataegus*, where the period during which fertilization can be effected is very short, a difference of only a day or two in the ripening of the pollen and the receptivity of the stigmas may make cross-pollenization in the wild state unlikely or impossible.

But in addition to the theoretical considerations that lend support to the belief in Crataegus hybrids some positive morphological evidence is found both in the intermediate characters of certain forms growing with others that may be the parent species, as well as in the high percentage of pollen sterility.

Standish,[1] who examined the pollen of 171 species, states that thirty-five of this number had normal pollen, sixty, from 10 to 50% sterility, forty-one, from 50 to 75%, and thirty-five from 75 to 100%. This would seem to indicate a large percent of hybrids or chromosome irregularity.

Longley,[2] who made studies of the chromosome structure, classes as diploids thirteen of the eighty-one species recorded, fifty-seven as triploids, and eleven as tetraploids and triploids. A considerable

[1] STANDISH, L. M. What is happening to the Hawthorns? (Jour. Heredity VII. 266–279. 1916.)

[2] LONGLEY, A. E. Cytological studies in the genus Crataegus. (Am. Jour. Bot. XI. 249–282. 1924.)

degree of variability in the seedling offspring of triploid or tetraploid species might normally be expected. But this, as stated above, has not been the experience with the species grown here and elsewhere, where records have been kept. The fact that so large a percentage of the forms come true to the parent type scarcely seems to lend support to the theory that they are of hybrid origin, and if that is admitted to be the case upon other evidence, it would seem to indicate that these triploid forms have developed a type of apogamous reproduction, as pointed out by Sax,[1] and as a consequence do not develop the variations of usual hybrids. My colleague, Dr. Karl Sax, has kindly furnished me with the results of some preliminary experiments which he has conducted to test this. The anthers and stigmas were decapitated before opening in 25 to 50 flowers of a number of selected species. Of the 39 species and varieties reported on, 16, or 41%, set fruit, ranging from one or two in most cases, to five in *Crataegus erecta*, seven in *C. pruinosa*, and eleven in *C. Oxyacantha plena*. In an experiment of this character it is also possible that injury to the flowers may have reduced the chance of setting fruit in some cases. This would seem to indicate clearly that apogamous reproduction does sometimes occur, but as in the cases of the other lines of investigation upon chromosome characters and sterility, these experiments have not so far been carried out on a sufficiently extensive scale to be conclusive in regard to many species, although they point to general conclusions. As an illustration *Crataegus pruinosa* appears to be a well marked species with a wide range. Standish reports 60% pollen sterility in the specimens of this species tested. Longley found it to be a triploid, while Moffett[2] reports it as a diploid. It is possible that the specimens selected were not in some cases pure-bred *C. pruinosa*. And it can easily be seen that any modification in the scheme of classification, such as changing the limits of the section, transferring species from one to another, or combining several so-called species into one, might materially alter results and conclusions based upon them. To further illustrate this: Standish found a high percentage of sterility amongst species of the *Intricatae* group, and she concludes that it is closely allied to *Coccineae*, and that all of the species of *Intricatae* may have arisen as hybrids between two species of the latter group or between one such species and some other parent. However, the ranges of the two groups are quite different from those shown on the map used

[1] Sax, Karl. The origin and relationship of the Pomoideae. (Jour. Arnold Arb., xii. 3–22. 1931.)

[2] Moffett, A. A. A preliminary account of Chromosome behavior in Pomoideae. (Jour. Pomology, ix. 100–110. 1931.)

to support this conclusion. The two groups do overlap in the northeastern states, but the wide range southward and westward shown for *Coccineae* results from following the treatment in Gray's Manual, which includes *Molles* with that group, and if this were done consistently the range would be more than twice as extensive. Attention may be called to the fact in this connection that Longley found the three species of *Molles* examined to be diploids and all of the twelve *Coccineae* to be triploids. The range of the *Intricatae* group also extends westward through Ohio, Indiana, Kentucky, Michigan, southern Illinois, the Ozark region of Missouri and Arkansas to eastern Oklahoma, and many of the species are found outside the range of any species of *Coccineae* or in a few cases of any *Molles* species. Moreover, on morphological grounds, I can see little evidence of a close relationship between the *Intricatae* group and the *Coccineae*, as understood here. Whatever the origin of certain of the *Intricatae* species may have been, the group as a whole is one of the better, although not one of the best, marked natural sections, and it appears to be more closely related to the *Pruinosae* and *Rotundifoliae* than to *Coccineae*. There is at least ground for suspecting that conclusions as to the status of some of the other species might be modified if experiments were carried out on a larger scale or with more certainty as to the correct identity of the material used, although this might not change the general trend of the evidence.

Two points, however, seem clear: the need of a sound taxonomic basis for all lines of botanical work, and that any classification to be of practical value must be based mainly upon morphological characters.

Sax concludes, in his paper on the origin of the Pomoideae, that: "On a genetic and cytological basis of classification all of the present genera of the Pomoideae might be classed as genetic species under one genus. In at least one case two genera should be combined under one species."

I think it safe to say that even our most conservative taxonomists and ardent "combiners" would scarcely approve of treating all of the forms of *Crataegus* of both hemispheres, including the genus *Mespilus*, as one polymorphic species.

Hybridization, therefore, seems to be a factor that must be reckoned with, but until much more experimental work has been done it is impossible to say how large a proportion of the recorded species, and in most cases which particular ones, originated in this way.

Where hybrids have arisen between two quite distinct and well

marked species or between those of two different groups, it may sometimes be detected by their intermediate characters or peculiar behavior, but this could only be done safely by careful field study and with data as to the species growing in the vicinity where the supposed hybrid originated, and as to the possibility of cross-fertilization. A hybrid between two closely allied species of the same group would be so obscure that they could scarcely be detected or identified on morphological characters, and to try to account for forms in this way, without experimental evidence, can be little more than a guess.

On the evidence available, as well as on theoretical grounds, it would seem then that the astonishing number of forms of *Crataegus* that have been detected and described are of diverse, and many of them probably of recent origin. First, there is a very large number of species and varieties that have arisen by what may be called, for want of more precise knowledge, the normal processes of evolution, and these can naturally be accounted for by the instability of triploid and polyploid species: second, there is probably a small number of hybrids between diploid, or between diploid and polyploid species, which may be expected to follow the Mendelian law of variability: and third, there is a perhaps larger group of hybrids between mostly triploid or polyploid forms, having pollen wholly or partly sterile, but which produce seed apogamously and therefore reproduce very closely all of the characters of the parent plants, thus fulfilling all of the evident requirements of normal species.

What disposition then should be made of the forms that have been described as species, of various degrees of distinctness and stability, a considerable number of which are probably of hybrid origin?

Since it has been found that the great majority of the forms grown from seed come surprisingly true to type, it seems to the writer that the practical thing to do in a general classification is to judge each recognizable form merely upon its morphological characters and where these seem sufficiently distinct to retain the specific name and treat it in all respects as a species, giving varietal rank to those less distinct. Where the evidence is available or as it becomes so, it will be desirable to indicate those species that are of hybrid origin, but the general student who is interested mainly in a workable basis for classification need not be greatly concerned with these.

The question of the relative value of the different morphological characters in diagnosing and describing species and varieties of *Crataegus* is also a debatable and perplexing one.

Professor Sargent placed strong emphasis upon the number of the stamens and the color of the anthers in distinguishing species, and Beadle, Ashe, and others also gave this as one of the key characters in many of their descriptions. So strongly was Sargent impressed with this, that in the writer's opinion, it was given undue value, and in some cases no other constant difference can be found between two described species except that of the number of stamens or the color of the anthers. Like many other characters, this seems to vary in constancy and value in the different groups and in different species within the groups. In the great majority of cases the seedlings which have been grown and studied here indicate that these characters come true with few exceptions, but that there are sometimes races or forms differing from each other only in the number of the stamens or the color of the anthers. This does not appear to me to be a satisfactory or sufficient distinction alone upon which to base species, although such races might be regarded as forms. The color of the anthers can only be determined in fresh material and for a few hours after the flowers open, and this is a practical disadvantage in using it as a key character in distinguishing species. But in some cases it seems to be the surest way of determining the identity of species where fresh flowers can be examined and mature foliage and fruit are not available.

In some species, and especially in some groups, pubescense on the foliage, young branchlets, inflorescence, or fruit is a valuable distinguishing character. But there are undoubtedly cases where this is variable and where there is both a glabrous and a pubescent form of a species. In some of the groups glands on the bracts, sepals, and leaves are abundant and conspicuous, while in some of the others they are rare or absent. This is often a valuable distinguishing character, but it is not always constant even within a species.

The size of the flowers, the number and arrangement in the corymbs, form of the ovary and calyx-lobes, the length of the pedicels and petioles, as well as the shape and serration of the leaves, are all significant characters but of varying degrees of constancy. Ecological conditions sometimes influence greatly the general appearance of a species and probably account for variability in many of these characters.

Some groups and species can be more readily distinguished by the mature leaves and fruit than in the flowering state, but the converse is also sometimes true. Perhaps mature fruit affords the best material for recognizing the groups, and often species may be

distinguished by this alone, but in all of the larger groups there are species in which the fruit is scarcely typical, or in which it is variable in size, shape or color, or sometimes in the thickness and consistency of the flesh, size of the calyx or number of the nutlets. The nest of nutlets often furnishes a definite clue to the group, but it is far too variable in some cases and there is too close a similarity in others to make it of much value in distinguishing species.

The leaves are parts of the plant that are nearly always available for study, and in a large proportion of cases, if specific lines are drawn fairly broadly, they possess recognizable differences. In fact, most of the sections or groups are distinguishable by the leaves alone. Of course it would be impossible to base a system of classification in so large a genus wholly, or even mainly, on leaf characters, but they perhaps furnish as many good characters, if both those of the fruiting branches and vigorous shoots, which often vary widely, are taken into account, as any other single feature, and they should be carefully considered in keys and descriptions.

It would have greatly simplified matters if any single organ or character, like the anther color, pubescence, glands, leaves or nutlets, were of constant value or varied consistently throughout the genus, but nature does not seem to work along lines of uniformity but upon those of the greatest diversity, and so it becomes impossible to follow any altogether uniform scheme in attempting to classify so large and variable a group as *Crataegus* into recognizable units. Any scheme adopted must be more or less eclectic and should recognize the fact that morphological characters that appear to be the most important in one section may not have equal value in another, and that each species is more or less a problem in itself.

From the foregoing I think it is apparent that the task of revising a genus of the size of *Crataegus* is a somewhat formidable one, and also one in which, with our present state of knowledge, no absolute finality can be expected. In some degree this is probably true of all taxonomic work. But it would seem that such a revision is urgently needed and that enough progress has now been made in understanding the genus to carry it out along conservative lines, that will neither seek to reduce arbitrarily species by throwing together as synonyms forms that are clearly recognizable, nor to maintain as species such as have proven to have been based on inconstant distinctions or morphological characters too slight or obscure to be worthy of specific rank. Such a treatment, while we cannot hope to devise a plan that will make a simple problem of a group of such large size and complexity and wide geographical

range, may at least do something towards simplifying it to a point where it will not be a hopeless task for the interested student to arrive at some knowledge of the principal forms or species, and if he is not particularly concerned with all the minor ones, he may do so without the expenditure of an unreasonable amount of time and study.

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CHROMOSOME RELATIONSHIPS IN THE POMOIDEAE

KARL SAX

With plate 50

THE ROSACEAE include four tribes or subfamilies which "are all closely linked together by their floral characters" (Rehder 1927.) The basic chromosome numbers are 8 and 9 in the Spiraeoideae, 7 and 9 in the Rosoideae, 8 in the Prunoideae, but it is 17 in all the genera of the Pomoideae. Polyploidy is found in all of these subfamilies although in the Pomoideae it is limited to triploids and tetraploids with very few exceptions.

According to Darlington and Moffett (1930) the 17 pairs of chromosomes in *Pyrus* are made up from a basic number of 7 by a duplication of 4 pairs and a triplication of 3 pairs of chromosomes. The Pomoideae are considered as complex autopolyploids and their morphological characters are attributed to this reorganization of the 7 basic chromosomes. These conclusions are based on the fact that there is a tendency for the chromosomes to be associated in groups of two or three pairs at meiosis and the fact that the basic chromosome is 7 in the more important genera of the Rosoideae. These authors also describe quadrivalent and sexivalent chromosomes at meiosis in diploid species.

The writer (Sax, 1931) and Moffet (1931a, 1931b) have found that all genera of the Pomoideae have 17 chromosomes as the basic number. The different genera are closely allied as shown by their morphological characters and their breeding and grafting relationships. They have undoubtedly had a common origin and the chromosome behavior should be similar in all genera.

In most genera there is a tendency for the bivalents to be grouped in the first meiotic division, but different genera seem to vary in this respect. The chromosomes of *Crataegus* and *Cotoneaster* do show secondary association to such an extent that consistent counts are difficult, but in *Sorbus*, *Aronia* and *Amelanchier* the 17 chromosomes of diploid species are well differentiated in most cases, although there is some evidence of secondary association.

The interpretation of the quadrivalent and sexivalent associations in diploid species may well be questioned. In most cases the multivalent "pairing" shown by Darlington and Moffett is based on the apparent contact between chromosome strands at late metaphase, although one diakinesis figure (text-fig. 11) is shown with one sexivalent, four quadrivalents and six bivalents. The con-

necting strands at late metaphase are about .05 micron in diameter and the difficulty in following these strands in side views in a metaphase figure containing 17 chromosomes makes any conclusions concerning multivalent associations rather questionable. It is probably significant that "multivalent" associations from side views were found far less frequently than those derived from polar views.

Later investigations by Moffett (1931b) show that there is little, if any, real multivalent pairing in diploid Pomoideae. At diakinesis he found that "in the great majority of divisions examined 17 bivalents were observed." The occasional "quadrivalents" shown in diploid species probably do not represent true pairing of four chromosomes but is simply a grouping of two bivalents due to secondary association.

If the Pomoideae are autopolyploids with sufficient homology and chiasma formation to permit multivalent chromosome association, the chromosomes in a triploid should form either multivalents or bivalents or both, but few if any univalents. There is, however, a large proportion of univalents in triploids. Only two or three univalents were found at metaphase in *Pyrus* by Darlington and Moffett, but at anaphase as many as 9 were found. In *Pyrus minima* (= *Sorbus minima*), Moffett shows as many as 12 to 15 univalents at metaphase and anaphase. The number of lagging univalents at anaphase is undoubtedly a better index of chromosome association than counts made at earlier stages, and simply confirms the conclusion that the multivalent associations found in diploids do not represent true pairing of chromosomes.

The writer has studied several triploid forms in the Pomoideae and has found a large proportion of univalents in all cases. *Sorbaronia alpina*, a hybrid between *Sorbus Aria* and *Aronia arbutifolia* (Rehder 1926), is a triploid. Judging from the appearance of this tree it has two sets of *Sorbus* chromosomes and one set of *Aronia* chromosomes. At the first meiotic division there are about 17 bivalents or trivalents and from 6 to 15 univalents. Polar views of the first meiotic division are shown in Figures 1 and 2. The univalents are usually found around, or at one side of, the bivalents and trivalents and usually not in the same plane as shown in the side views. (Figs. 3 and 4.) It is not possible to distinguish between bivalents and trivalents in polar views and even from side views of the division figure the trivalents are not easily differentiated. There are, however, usually 17 pairs or multivalent associations of chromosomes so that the deficiency of univalents must be accounted for on the assumption that some trivalents are formed.

A few trivalent chromosomes can be observed from side views. If pairing occurs between the extra 17 chromosomes we would expect about 24 bivalent chromosomes and one univalent. At anaphase the univalents lag behind and ultimately divide. The most usual number of lagging univalents found is 11 or 12. (Figs. 5 and 6.) This observation is in accord with the numbers found at metaphase.

Sorbopyrus auricularis bulbiformis is also a triploid and as previously described (Sax 1931) it has about 12 univalents at the first meiotic division. (Fig. 7.)

Malus theifera is another triploid which shows some univalents at the first meiotic division. (Fig. 8.) The divisions in the pollen mother cells are very irregular and practically no pollen grains are found in the mature anthers. The division in the megaspore mother cell is more regular and apparently trivalents are formed with only an occasional univalent chromosome. This species sets an abundant crop of fruit, the seeds are fertile and the seedlings are all true to type. The fact that this species is a triploid and has no functional pollen, but breeds true from seed, indicates that apomictic development occurs. The details of embryo origin and development have not yet been determined.

The evidence from triploid Pomoideae clearly indicates that there is little or no pairing among the extra 17 chromosomes and that this subfamily is not an autopolyploid with a basic number of 7 chromosomes. There is of course the possibility of autopolyploid origin so early that the originally homologous chromosomes have been so differentiated that they now show only weak affinities. But the Pomoideae are apparently of comparatively recent origin as indicated by the fertility of species and even generic hybrids, and the comparative morphology of the different genera.

It seems much more probable that the Pomoideae are allopolyploids derived from parental types with 8 or 9 chromosomes. In all other subfamilies of the Rosaceae the basic chromosome numbers for almost all genera are 7, 8, or 9. In the Spiraeoideae the basic number is 8 for *Spiraea* and *Exochorda* and 9 for *Physocarpus*, *Pentactina*, and *Sibiraea*. Hexaploid species have been found in *Spiraea*.

In the Rosoideae the basic chromosome numbers are 7 and 9. The larger genera such as *Rosa*, *Rubus* and *Potentilla* have a basic number of 7 chromosomes, but the monotypic genera *Rhodotypus*, *Kerria* and *Neviusia* each have 9 pairs of chromosomes. (Figs. 9, 10, 11.) The writer (Sax 1931) previously reported 8 pairs of chromosomes in *Rhodotypus* and *Neviusia*, but there are apparently 9 pairs. The fact that two pairs may be so closely associated that

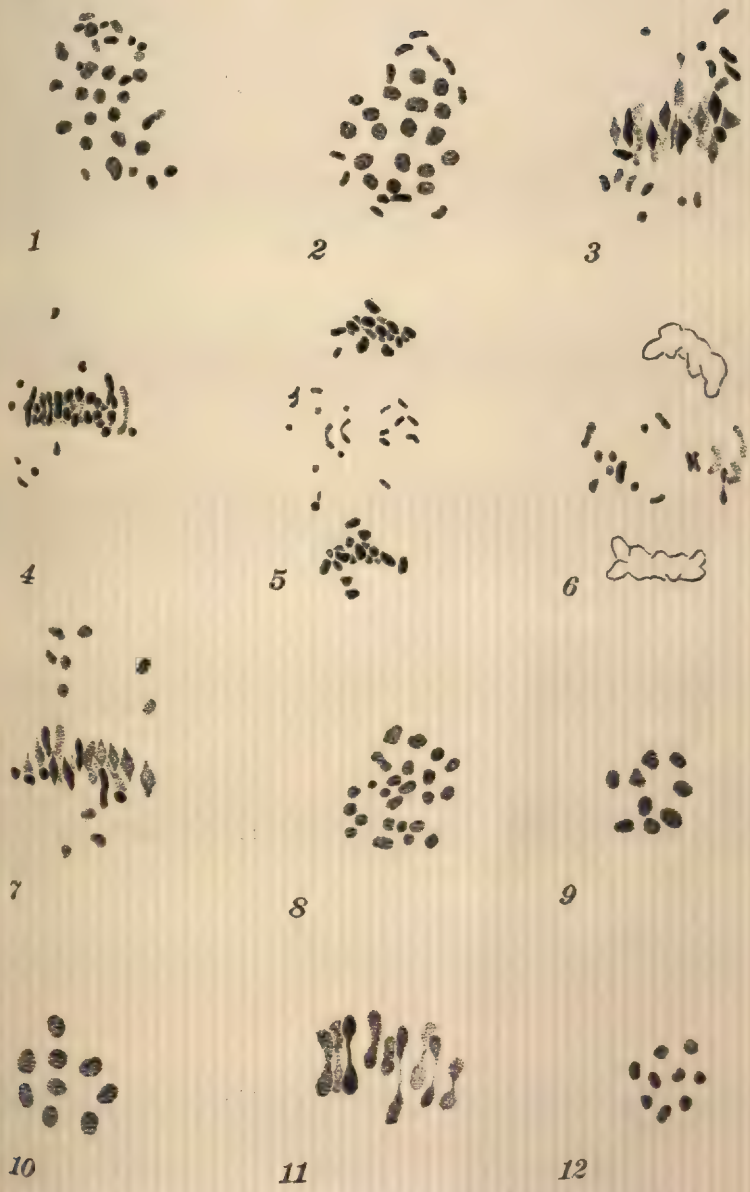
counts are difficult suggests that some chromosome duplication may have occurred in these genera. If the Pomoideae have been derived from other subfamilies in the Rosaceae, it would seem that the Spiraeoideae and Rosoideae were involved. My colleague Mr. Rehder tells me that the Pomoideae are taxonomically more closely allied to the Spiraeoideae than to either of the other two subfamilies. Crosses between earlier types of Spiraeoideae or perhaps between primitive forms of Spiraeoideae and Rosoideae may have been the basis for the origin of the Pomoideae. Hybrids between forms close enough to cross would indicate some chromosome homologies although perhaps not close enough for chromosome pairing. Doubling of the chromosome number in the F_1 hybrid would insure fertility and an allotetraploid would be produced with 17 chromosomes. The recent production of allotetraploids in different families shows that such an origin of a new type of plant is quite possible.

In such an allotetraploid there might well be sufficient affinities to produce some secondary pairing of bivalent chromosomes although real pairing to form quadrivalents would rarely or never occur. Some secondary pairing may have been present in one of the contributing diploids as suggested by the chromosome behavior in *Rhodotypus* and *Neviusia*. Lawrence (1931) has presented good evidence that secondary association of bivalents does occur in many genera, apparently due to remote affinities between chromosomes which are too well differentiated to permit multivalent chromosome pairing. As Lawrence points out such allopolyploids would have a high survival value due to hybrid vigor and a high degree of fertility. The differentiation of genera and species within the Pomoideae can be attributed primarily to mutations or minor changes in the 17 pairs of chromosomes.

SUMMARY

Sorbaronia alpina, *Sorbopyrus auricularis* and *Malus theifera* are triploids. At the first meiotic division in the pollen mother cells there are about 17 bivalents and trivalents, and from 6 to 15 univalent chromosomes. The fact that about 12 univalents are usually found in triploid forms of Pomoideae shows that this subfamily is not an autopolyploid with a basic number of 7 chromosomes as several writers have suggested.

The basic chromosome numbers in the other subfamilies of the Rosaceae are 7, 8, and 9. The Pomoideae may have originated from one or perhaps two of these subfamilies by hybridization between different primitive forms followed by chromosome doubling



Chromosome Relationships in the Pomoideae.

in the F_1 hybrid. Remote chromosome affinities are indicated by secondary association of bivalents in the Pomoideae. True multivalent chromosome pairing rarely, if ever, occurs in "diploid" species. The available evidence seems to indicate that the Pomoideae are allopolyploids.

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EXPLANATION OF PLATE 50

Figures 1, 2, 3, 4, 5, and 7 are from permanent smear preparations of pollen mother cells. The other figures are from aceto-carmine preparations. Magnification × 3000, except Figure 8 which is × 2100.

Figures 1–6. *Sorbaronia alpina*, first meiotic division, showing from 9 to 15 univalents at different stages and about 17 bivalents and trivalents.

Figure 7. *Sorbopyrus auricularis bulbiformis*, first metaphase, with 14 univalents.

Figure 8. *Malus theifera*, a triploid with univalents and bivalents or trivalents. No functional pollen is produced.

Figure 9. *Neviusia alabamensis*, second metaphase, 9 pairs of chromosomes.

Figure 10. *Rhodotypus scandens*, first metaphase, 9 pairs of chromosomes.

Figure 11. *Kerria japonica*, first metaphase, 9 pairs of chromosomes.

Figure 12. *Physocarpus monogynus*, first metaphase, 9 pairs of chromosomes.

CHROMOSOME PAIRING IN LARIX SPECIES

HALLY JOLIVETTE SAX

With plate 51 and one text figure

THE CONIFERS show a remarkable uniformity in chromosome number. With few exceptions all the genera have twelve pairs of chromosomes (Tischler 1927). No polyploid species have been reported, and the meiotic divisions seem to be very regular. Chromosome behavior in species hybrids has never been described in the Gymnosperms.

This study was undertaken to determine whether or not there is any cytological basis for the uniformity in chromosome numbers in the Conifers, and to analyze the chromosome behavior in a species hybrid. The meiotic chromosomes have been examined in *Pinus*, *Tsuga*, *Taxus*, *Picea*, *Pseudolarix*, *Cedrus*, and *Larix*. The meiotic chromosomes are similar in all the above genera. The present analysis will be confined to two species of *Larix* and an F_1 hybrid. A more detailed analysis of chiasma formation and chromatid relationships at meiosis will be published later.

Larix eurolepis Henry is a hybrid between *L. Kæmpferi* Sarg. and *L. decidua* Mill. This hybrid is intermediate in appearance between the parental species, but possesses considerable hybrid vigor and matures its cones earlier than either parent. An account of the origin and characteristics of this hybrid has been recently published by Anderson (1931).

Larix Kæmpferi is a native of Japan, while *L. decidua* is indigenous to northern and central Europe (Rehder 1927). This distribution of the two species would indicate that the parental types had been separated for long periods of time.

The material for the present paper was taken from specimens of these Larches growing in the Arboretum. The divisions in the pollen mother cells occurred during very cold weather. The time of division in the hybrid was between that of the two parents. During the last week in February the pollen mother cells were found dividing in *L. Kæmpferi*. *L. eurolepis* produced dividing pollen mother cells throughout the first week in March. The divisions in *L. decidua* occurred the following week. Other specimens of *L. decidua*, from a different part of the Arboretum and from a different slope, were a little more advanced in this respect. Material was obtained over a period of several days in each case.

Permanent smears of the pollen mother cells were made. A number of fixatives were used. Darlington's modification of Flemming's fixative proved to be the best for *Larix*. The crystal violet-iodine stain gave the best results for work on the chromosomes.

Within a given genus chiasma frequency in the meiotic chromosomes is evidently a good index of chromosome affinities and provides an accurate method for measuring the degree of chromosome pairing in species and generic hybrids. Aase (1930) noted the greater frequency of univalents and open (single chiasma) types of bivalents in *Triticum* × *Aegilops* hybrids than in the parents. Although Aase did not use the term "chiasma" in her description of chromosome pairing, the different types of bivalents were observed and discussed. Darlington (1931b) and Hollingshead (1932) have corroborated Aase's observations in *Triticum* hybrids, and they have discussed the problem from the standpoint of chiasma frequency.

THE MEIOTIC CHROMOSOMES.

The twelve bivalents from one nucleus of *Larix decidua* are shown in figure 1. These were drawn from a side view of the metaphase figure. Each chromosome was drawn separately so that details of pairing might be observed. The chromosomes of *L. eurolepis*, the hybrid, are shown in figure 2, and those of *L. Kæmpferi*, in figure 3.

The nodes are undoubtedly chiasmata, and the cross formed by the exchange of partners among the four chromatids can be observed in many chromosomes. Most of the chiasmata are approximately median or subterminal in respect to the spindle fiber attachment and the distal ends of the chromosomes. In many cases the chiasmata are terminalized with difficulty, and the chromosomes are stretched into thin strands between the fiber attachments and the chiasmata. (Figure 2b and c.) Consecutive internodes are oriented in planes more or less at right angles to each other. There is a wide separation of free arms at the distal side of the chiasmata as well as between the chiasmata. In the smear preparations no spindle fibers were observed, although, with the same fixative, paraffin sections show clear spindle fibers.

Pairing of bivalent chromosomes in *Larix* and other Conifers seems to be effected only by chiasmata,—a condition which Darlington (1931a) believes to be true for all genera. The prevalence of interstitial chiasmata at diakinesis and early metaphase indicates that there is little terminalization of chiasmata during the prophase stages of meiosis.

CHIASMA FREQUENCY IN LARIX SPECIES AND F_1 HYBRID

Chiasma frequency can easily be observed in *Larix* at diakinesis and metaphase of the meiotic divisions. Counts were made in pollen mother cells where all twelve bivalents could be clearly observed. The data are summarized in Table I.

TABLE I

Chiasma frequency in Larix species and F_2 hybrids

	Number of cells counted	Number of Chiasmata						Total number of chromosomes	Average number of chiasmata
		0	1	2	3	4	5		
Larix decidua	37		19 4%	279 63%	110 25%	36 8%	0	444	2.36 ± .02
Larix eurolepis	51	4 .7%	49 8%	294 48%	198 32%	66 10.7%	1 .001%	612	2.45 ± .02
Larix Kæmpferi	46		88 16%	223 40%	139 25%	98 18%	4 .007%	552	2.47 ± .03

In *Larix decidua* the chiasma frequency ranges from one to four per bivalent with an average of 2.36. In *L. Kæmpferi* the range is from one to five with an average of 2.47 chiasmata per bivalent. No univalents or precocious divisions were found in these species. In the F_1 hybrid (*L. eurolepis*) the chiasma frequency is from zero to five, and the average per bivalent is 2.45. The hybrid is intermediate between the two parents, although the chiasma frequency is nearer that found in *L. Kæmpferi*. The differences in mean chiasma frequency are of doubtful significance, although these differences between the parents and between *L. decidua* and the hybrid are about three times the probable error. Univalents or precocious divisions of one bivalent were found in about eight per cent of the pollen mother cells of the hybrid. In practically all cases observed, these single chromosomes were passing to opposite poles, so that a normal distribution of chromosomes would be expected.

The distribution of chiasma frequency is shown graphically in Text figure 1. The curve of chiasma frequency in the hybrid is intermediate between those of the parental species, but the differences in the curves are of doubtful significance. The shape of the curves is similar to the condition found in *Vicia* by Mæda (1930),

which Haldane (1931) attributes to interference in chiasma formation.

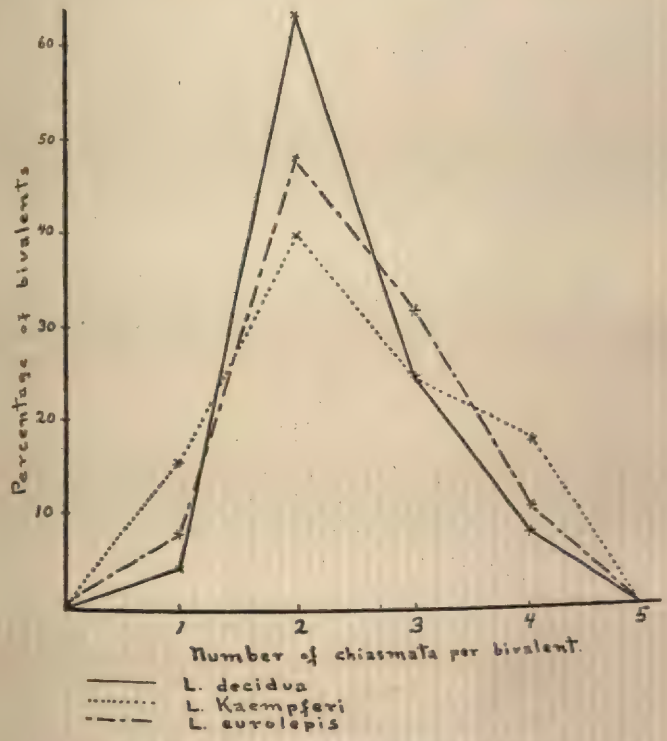

FIG. 1. CHIASMA FREQUENCY IN LARIX.

In view of the great regularity in the chromosome number, as well as the similarity in chiasma frequency between the parents and the hybrid, very little pollen sterility was expected. Counts of good and bad pollen in the parents and hybrid show greater sterility in the hybrid than in either parent. The counts and percentages of poor pollen are recorded in Table II.

TABLE II

Pollen sterility in Larix species and F_1 hybrid

	good pollen	poor pollen	percentage of poor pollen
Larix decidua	614	14	2.2%
Larix eurolepis (L. Kæmpferi × L. decidua)	866	85	9.2%
Larix Kæmpferi	1030	29	2.7%

DISCUSSION

The uniformity in chromosome numbers for most genera of the Gymnosperms, and the absence of recorded cases of polyploidy, can perhaps be attributed to the type and frequency of chiasma formation at meiosis. With an average of about 2.4 interstitial chiasmata per bivalent, any autopolyploids produced would be expected to form closely paired tetravalents. The segregation of homologous chromosomes in such polyploids would probably be too irregular to produce a high degree of fertility, and the polyploid would have small chance of survival. Very few polyploid species occur in nature where the chromosomes pair as quadrivalents at meiosis. The only known case where a high percentage of quadrivalents is found in fertile species is in the tetraploid Tradescantias (Anderson and Diehl 1932). In these species the spindle fiber attachment point is approximately median, and the chiasmata are largely terminal in both diploids and tetraploids. The chromosome morphology and types of chiasmata formed might permit rather free movements of the homologous members of a quadrivalent, so that regular chromosome distribution and a high degree of fertility might be expected. With a high frequency of interstitial chiasmata, regular assortment and fertility would not be expected in autopolyploids. The absence of polyploid species of Conifers may also be dependent on other factors, in addition to the type and frequency of chiasma formation.

If chiasma frequency is a good index of chromosome homology, as has been shown by several writers, the chromosome constitutions of *L. decidua* and *L. Kæmpferi* appear to be very similar. The average chiasma frequency is approximately the same in the parental species and the F_1 hybrid. There is, however, a tendency toward weak pairing between two of the homologous chromosomes in the hybrid. In about eight per cent of the figures examined, two homologous chromosomes were not paired at early metaphase, although these two homologous chromosomes seem to pass to opposite poles. Apparently these two chromosomes are not completely homologous, but the average chiasma frequency found in the hybrid is not lower than that found in the parents.

About nine per cent of the pollen in the F_1 hybrid is morphologically imperfect as compared with two or three per cent found in the parental species. The increased pollen sterility of the hybrid can not be due to irregularities in chromosome distribution at meiosis.

SUMMARY

A detailed analysis was made of chromosome pairing in *Larix Kæmpferi*, *Larix decidua*, and a hybrid between these two species (*Larix eurolepis*). The chromosome number and the type of chiasma formation is similar in the three species and in the remainder of Conifers studied. The comparatively high number of chiasmata, together with the prevalence of the interstitial chiasmata formed here, may account largely for the great uniformity in chromosome number and general stability in the group.

The chiasma frequency was remarkably similar in all three species. The average chiasmata frequency per bivalent was 2.36 for *L. decidua*, 2.47 for *L. Kæmpferi*, and 2.45 for *L. eurolepis*.

Although there were a few cases where there was weaker pairing in the homologues in one bivalent of the hybrid, chromosome distribution appeared to be regular, and the average chiasma frequency was as high as that in the parents. The pollen sterility was somewhat greater in the hybrid than in the parents. This greater pollen sterility in the hybrid can not be attributed to irregular chromosome distribution or to difference in chiasma frequency.

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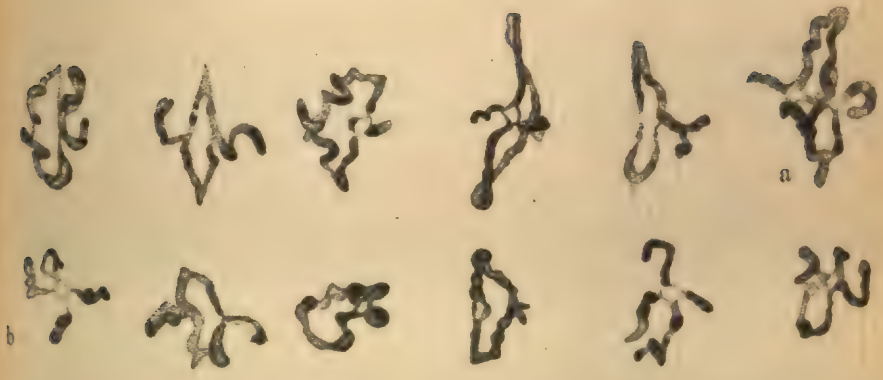
EXPLANATION OF PLATE 51.

The figures in Plate 51 were all drawn from side views of permanent smears of pollen mother cells fixed in a modification of Flemming's solution and stained with crystal violet-iodine. Each figure shows all the chromosomes of one cell at meiotic metaphase. The drawings were made with the aid of a camera lucida. Magnification × 2600.

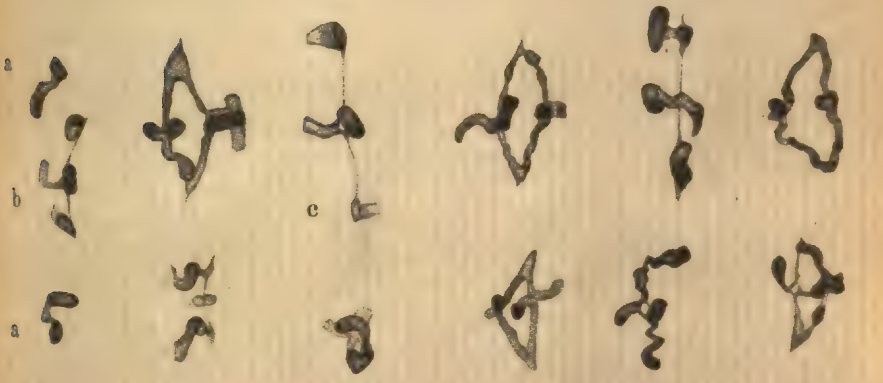
Figure 1. *Larix decidua.* Chiasmata distinct, few terminal, most subterminal. (a) Two subterminal chiasmata. (b) Chiasma nearer fiber attachment.

Figure 2. *Larix eurolepis* (L. Kæmpferi × L. decidua). a, a, univalents near poles. b, c, chromosomes each with chiasma near fiber attachment.

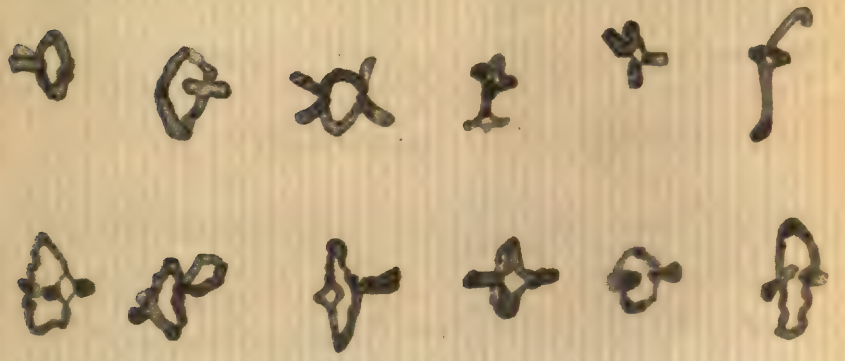
Figure 3. *Larix Kæmpferi.* Slightly earlier than above.



1



2



3

Chromosomes of Larix

MEIOSIS AND CHIASMA FORMATION IN PÆONIA SUFFRUTICOSA

KARL SAX

With plate 52 and two text figures

THE GENETIC evidence has shown conclusively that crossing over occurs at the four strand stage and between only two of the chromatids at any one locus (Bridges and Anderson 1925, et al.). An actual physical interchange of chromosome segments has been shown to be correlated with genetic crossing over in *Drosophila* (Stern, 1931) and in *Zea* (Creighton and McClintock, 1931). Such an interchange of chromosome segments should invariably produce an asymmetrical arrangement of the chromatids. If chiasmata are produced by previous crossovers, each chromatid will not always lie in the same quadrant at all loci. A study of chromatid organization at meiosis should throw some light on the nature of chiasma formation.

In this discussion the term *chiasma* is used to denote an apparent change of partners among the chromatids at meiosis without reference to the origin of such configurations.

If chiasmata are caused by the alternate pairing of sister and non-sister chromatids, the sister chromatids will be paired on one side of a chiasma, and homologous threads will be associated on the other side of the chiasma, as shown in diagram 1 (Fig. 1). Viewed from one angle, two of the chromatids seem to cross each other, but from another angle the other two chromatids form the cross. The apparent cross at each chiasma is formed by diagonal rather than adjacent chromatids. Each chromatid will lie in the same quadrant at all loci if no crossovers or twists in the chromatids have occurred. The pairs of chromatids on either side of a chiasma would be expected to open out at right angles to each other.

Chromosome configurations which seem to support this interpretation of chiasma formation have been described and pictured by Wenrich (1916), Robertson (1916), McClung (1927), Wilson (1925), Bělař (1928), Carothers (1927), Taylor (1930), and others. Only in a relatively few cases is there any twisting of paired chromatids in the meiotic chromosomes pictured by these investigators, and in most cases each chromatid lies in the same quadrant at all loci. As McClung has pointed out, the clearest figures shown by Jannsens (1924) also show the chromatids in the same quadrants at all loci.

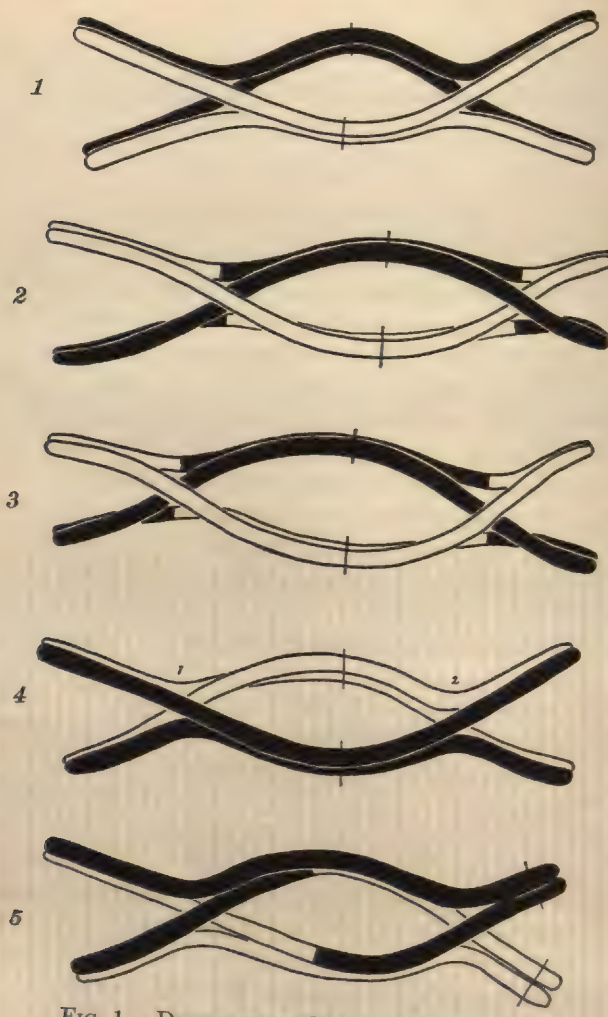


FIG. 1. DIAGRAMS OF CHIASMA FORMATION.

One pair of sister chromatids is represented by white rods and the other pair by black rods. The spindle fiber attachment points are indicated by cross lines. The term *chiasma* is used to designate the change of partners among the four chromatids of a meiotic chromosome without reference to its origin.

Diagram 1. Chiasma formation as interpreted by McClung and others. A chiasma is caused by the alternate opening out of sister and non-sister chromatids in pairs. As viewed from the end, each chromatid maintains its position in the same quadrant at all loci. Alternate internodes lie in planes at right angles to each other.

Diagrams 2 and 3. Chiasma formation according to Jannsens' partial chiasmatypy hypothesis. Each chiasma is the result of a previous crossover between two of the four chromatids. Two of the chromatids do not maintain

their position in the same quadrants at all loci. The pairs of chromatids on both sides of a chiasma should tend to lie in the same plane.

Diagram 4. Chiasma formation according to McClung's interpretation, but with 2 chromatids in different quadrants at different loci, due to a half-twist in one pair of chromatids before pairing.

Diagram 5. A chiasma similar to number 1 of diagram 4, but the half twist is caused by a crossover resulting from breaks in two chromatids of a previous median chiasma. A bivalent of this type might lead to interlocking of homologous chromosomes at the first meiotic metaphase, and in this respect resembles the configuration shown in diagram 2.

Darlington (1930, figs. 8, 9, 10) and Moffett (1932, diagrams 2A, 2B), have published diagrams of chiasma formation which are in accord with McClung's interpretation. More recently Darlington and Dark (1932) have shown figures of bivalent chromosomes of *Stenobothrus* where the relations of the four chromatids can be observed at all loci in some of the chromosomes. The chromatids in the shorter chromosomes usually show a symmetrical arrangement, as would be expected if chiasmata are produced by alternate opening out of sister and homologous chromatids at diplotene. In the long bivalents pictured by Darlington and Dark it is difficult to follow the position of the chromatids at all loci, but some of the chiasmata in these chromosomes are clearly symmetrical, although some bivalents (D, fig. 6) do show asymmetrical arrangements of the chromatids. The double chiasmata analyzed were always (?) "compensating" (reciprocal) and never diagonal (equational). In *Drosophila* both types of crossovers occur with about equal frequency.

According to Jannsen's (1924) partial chiasmatypy hypothesis, a chiasma is produced by crossing over between two of the four chromatids (Fig. 1, diagrams 2 and 3). This interpretation has recently been sponsored by Belling (1931), Darlington (1931), and others. In all cases it is assumed that sister chromatids are paired at all loci, and that each chiasma represents a crossover. As shown in diagrams 2 and 3, two chromatids would not lie in the same quadrant at all loci, and the two chromatids which form the cross should be adjacent and not diagonal. At diplotene and subsequent stages the pairs of chromatids should lie in the same plane on either side of a chiasma and not at right angles to each other. As shown in another paper (Sax 1932), it is also necessary to assume, on Belling's hypothesis, that crossovers occur between sister chromatids which would produce many twists in paired sister chromatids between chiasmata. Certain types of double crossovers should result in interlocking of homologous chromosomes at metaphase, as would be the case if the spindle fiber were terminal in diagram 2 (Fig. 1). It is possible, of course, that the movement

of the chromatids would occasionally result in a symmetrical configuration where each chromatid would lie in the same quadrant at all loci, but such figures should be rare.

The most critical studies of chromatid organization and the nature of chiasma formation have been based on preparations of Orthopteran chromosomes. In this group of animals the four chromatids can often be recognized at all loci at the diplotene stage. In plant species, however, the chromatids are usually closely paired in spiral chromonemata during late prophase and early metaphase stages so that the individual chromatids can seldom be differentiated until the anaphase stage of meiosis. Newton's (1926) figures of *Tulipa* and *Fritillaria* chromosomes do show the tetrad nature of the meiotic chromosomes to some extent. According to Newton, the hypothesis "which explains the diakinetic figures as due to the opening out in two planes at right angles of what are originally four parallel chromatids, is adequate to explain the events of diakinesis and division in *Tulipa* and *Fritillaria*." Taylor's (1930) figures of *Gasteria* chromosomes show clearly the alternate opening out of the chromatids in pairs at right angles to each other, with each chromatid in the same quadrant at all loci. Some of his figures also show the chromatids opening out in pairs at the proximal end, but at the distal end all four chromatids are paired. Such chromosome pairing without chiasma formation can not be reconciled with Darlington's (1931) theory of chromosome pairing at meiosis. According to Darlington, chromosomes are associated only by chiasmata at the first meiotic division. In many species bivalent chromosomes are apparently associated only by chiasmata at the meiotic metaphase.

In numerous species of plants it is clear that alternate internodes of meiotic chromosomes are oriented in planes at right angles to each other, as is the case in the multiple ring chromosomes of Orthopteran species.

CHIASMA FORMATION IN PÆONIA

Pæonia suffruticosa has five pairs of large chromosomes. The haploid set of chromosomes at metaphase of the microspore division is shown in text-figure 2. Four of the chromosomes have an approximately median spindle fiber constriction, while the fifth chromosome has a subterminal fiber attachment with a trabant at the end of the short arm. The somatic chromosomes are long and slender, and even at metaphase the paired chromatids are often twisted about each other (Figure 1 of pl. 52). If the sister chromatids of homologous chromosomes are twisted at the

time of pairing at meiosis, then the chromatids will have an asymmetrical arrangement at the diplotene stage. Such meiotic chromosomes should often show half twists in paired chromatids, even if no crossovers have occurred.

The chromosomes at the meiotic prophase were so diffuse and granular in appearance that any critical study of early chiasma formation was impossible. Relatively few chiasmata seem to be present, even at the early prophase. At diakinesis the number of nodes or chiasmata can be clearly observed, but the relation of the chromatids was obscure.

FIG. 2. CHROMOSOMES IN PÆONIA MICROSPORE.

The four chromatids can usually be observed at the first meiotic metaphase, and in many cases the relations of the chromatids can be determined at all loci. The chromatids are always closely associated in pairs at the spindle fiber attachment point, but at other loci they may be well separated.

Many of the meiotic chromosomes are paired without the formation of chiasmata (Figures 4a, 4d, 7a, 10b of pl. 52). The sister chromatids appear to be paired throughout their length with no exchange of partners at any locus. At the proximal ends the chromatids have opened out in pairs, but at the distal ends all four chromatids seem to be paired. If non-sister chromatids in such figures were to open out in pairs at the distal ends, then we would expect a chiasma to be formed as shown in figure 9 (pl. 52). Only in rare cases do the distal ends of the chromatids open out to form the cross-shaped figure which is so typical in many other genera. In many cases, however, there is some separation of the paired chromatids at the distal ends of the chromosomes (Figures 2, 5,

11a of pl. 52). Homologous chromosomes which are paired at both ends usually show the sister chromatids paired only at the spindle fiber attachment and pairing of non-sister threads only at the distal ends (Figures 4b, 6b, 7c, 7d of pl. 52).

Half twists in paired chromatids are often observed (Figures 2a, 3d, 4a, 8a, 10a of pl. 52). Such half twists between the fiber attachment and the first chiasma would be expected even if no crossing over occurs.

If crossovers have occurred in the meiotic chromosomes, there should be half twists or an asymmetrical arrangement of the chromatids, but in many cases the chromatids are symmetrical and lie in the same quadrants at all loci (Figures 4c, 4d, 5, 6b, 7a, 7b, 7d of pl. 52). In the chromosomes with a single chiasma it is possible that any earlier asymmetrical relations of the chromatids might be straightened out, in some cases, by the movements of the chromatids during the early stages of division. In chromosomes with a median fiber attachment and two terminal chiasmata, such a change in the relation of the chromatids would be improbable. In some of these chromosomes there are half twists in the chromatids (Figures 4b, 7c, and 8a of pl. 52), but other bivalents show the symmetrically arranged chromatids in the same quadrants at all loci (Figures 6b and 7d of pl. 52). Half twists in the chromatids of such chromosomes may be due either to twisting before the homologues pair or to crossing over. No crossovers could have occurred in the symmetrical chromosomes, even though two chiasmata are present in each pair of chromosomes. Although these chromosomes do not have the usual types of chiasmata, the situation is essentially the same as in the multiple ring chromosomes in Orthoptera where each chromatid lies in the same quadrant at all loci (Fig. 1, diagram 1). Such figures are very difficult to interpret on the basis of the partial chiasmatypy hypothesis.

There are, however, some chromosome configurations which do support the partial chiasmatypy hypothesis. In these chromosomes the chiasma cross is formed by chromatids which were adjacent, rather than diagonal, at the four strand stage (Figures 6a and 11b of pl. 52). In these figures the two upper chromatids form the cross and lie above the other two chromatids on each side of the cross. Such a relation of the chromatids should be characteristic if chiasmata are caused by previous crossovers, as shown in diagrams 2 and 3 (Fig. 1).

This type of chiasma is difficult to account for on the hypothesis that chiasma formation precedes crossing over. If no twists occur

in pairs of sister chromatids, the chromatids which form the cross will be diagonal on each side of the chiasma (Fig. 1, diagram 1). If a half twist occurs in one pair of sister chromatids, the chromatids which form the cross will be adjacent on one side of the chiasma, but will be diagonal at the distal end, as shown in diagram 4 (Fig. 1). A rotation of the chromatids in the lower left-hand arm of this chromosome would produce a configuration like those found in figures 6a and 11b (Pl. 52), but such behavior of the chromatids might be expected only in rare cases.

The homologous chromosomes occasionally fail to pair or are separated before the first meiotic metaphase. The univalent chromosomes may pass to opposite poles (Figure 4 of pl. 52), or they may pass to the same pole (Figures 8 and 12 of pl. 52). The segregation of both homologous univalents to the same pole will result in genetic "non-disjunction" if the gametes are viable. (For further discussion, see previous paper, Sax 1932.)

Occasionally a bivalent chromosome divides with apparent difficulty, even when there is no interlocking of paired chromatids. In figure 12 (Pl. 52) a bivalent is shown held together by the attachment of two single chromatids. Such figures are common in many species.

No interlocking of homologous chromosomes was observed in *Pæonia*, and none would be expected where only one chiasma is formed between the spindle fiber and the distal end of the chromosome. Where several chiasmata are formed, some interlocking of chromosomes would be expected, and such types of bivalents are found in the Orthoptera, and in *Lathyrus* and *Lilium*. If chiasmata are formed by previous crossovers, the configuration shown in diagram 2 should result in interlocked chromosomes if the spindle fiber attachment were terminal. On the writer's hypothesis a crossover between two unbroken chiasmata should also result in interlocked homologues at metaphase (Fig. 1, diagram 5).

PRE- AND POST-REDUCTION

The genetic evidence shows that in *Drosophila* the sister chromatids are always paired at the spindle fiber attachment point during the first meiotic division (Bridges and Anderson 1925, et al.). In numerous species of plants and animals the paired chromatids are associated only at the point of spindle fiber attachment at the anaphase and telophase stages of the first meiotic division, and this association is often especially clear during interphase. Since the spindle fiber attachment points can sometimes be observed soon after the chromosomes pair and before the diplotene stage, it

seems probable that sister chromatids are usually held together at the fiber constriction, as is clearly the case in *Drosophila*. Such an association of chromatids would mean that the first meiotic division is reductional at the fiber constriction and for all loci between the fiber constriction and the first crossover. Between the first crossover and the distal end of the bivalent chromosome the division is equational. If a second crossover occurs on the same side of the spindle fiber, the loci distal to the second crossover would undergo pre-reduction at the first meiotic division.

Wenrich (1916) and Carothers (1931) have described both pre- and post-reduction in heteromorphic chromosomes. According to Wenrich (figure 65) chromosome "C" in *Phrynotettix* forms only a single chiasma. One of the homologues is shorter than the other, and the two short chromatids are always paired. In about half the cases the first meiotic division is reductional, and in half the cases it is equational. On any theory of chiasma formation it would be impossible to obtain both types of reduction with only a single chiasma and a constant association of short chromatids unless the spindle fiber can be attached more or less at random to either end of the homologous chromosomes. But the spindle fiber attachment point seems to be constant for individual chromosomes of both plants and animals. In Wenrich's figure 64, showing the behavior of the unequal chromosome pair B, the segregation is equational, but in order to have an equational division, it would be necessary to assume that non-sister threads are paired at the fiber constriction or that a crossover has occurred in all cases.

Similar heteromorphic chromosomes in *Trimerotropis* have been described by Carothers (1931). The unequal homologues may undergo either pre-reduction or post-reduction, although in the few figures showing chromatid association, only a single chiasma is present, and the short chromatids are always paired. If the first meiotic division can be either pre-reductional or post-reductional, it is necessary to assume that some crossing over occurs if sister chromatids are always paired at the point of spindle fiber attachment. The behavior of unequal homologues should receive further study in connection with the implications involved concerning crossing over and the nature of chiasma formation.

SUMMARY

If chiasmata are formed by the alternate pairing of sister and non-sister chromatids, each chromatid may lie in the same quadrant at all loci. An asymmetrical relation of the chromatids can exist only if sister chromatids are twisted before or after synapsis or if a crossover has occurred.

If chiasmata are the result of previous crossovers, the chromatids should not lie in the same quadrants at all loci, and symmetrical arrangements of the chromatids should seldom be found.

In *Pæonia suffruticosa* the homologous chromosomes may pair at meiosis without chiasma formation. When chiasmata are found, the chromatids are often symmetrical in the bivalent chromosomes. The symmetrical relations of the chromatids in bivalents with two chiasmata are very difficult to explain on the partial chiasmatypy hypothesis. These figures are essentially the same as the types found in Orthopteran species.

Most of the asymmetrical configurations found in the *Pæonia* chromosomes could be attributed to half twists in paired sister chromatids. Some chiasmata are found, however, where the chromatids forming the cross are adjacent on both sides of the chiasma. Such a relation of the chromatids supports the partial chiasmatypy hypothesis of chiasma formation.

Occasionally one or more homologous chromosomes are not paired at the first meiotic metaphase, but pass to the poles as univalents. The segregation of two homologues to the same pole would result in genetic "non-disjunction."

In some cases homologous chromosomes are paired without chiasma formation.

Pre- and post-reduction divisions are discussed in relation to the nature of chiasma formation.

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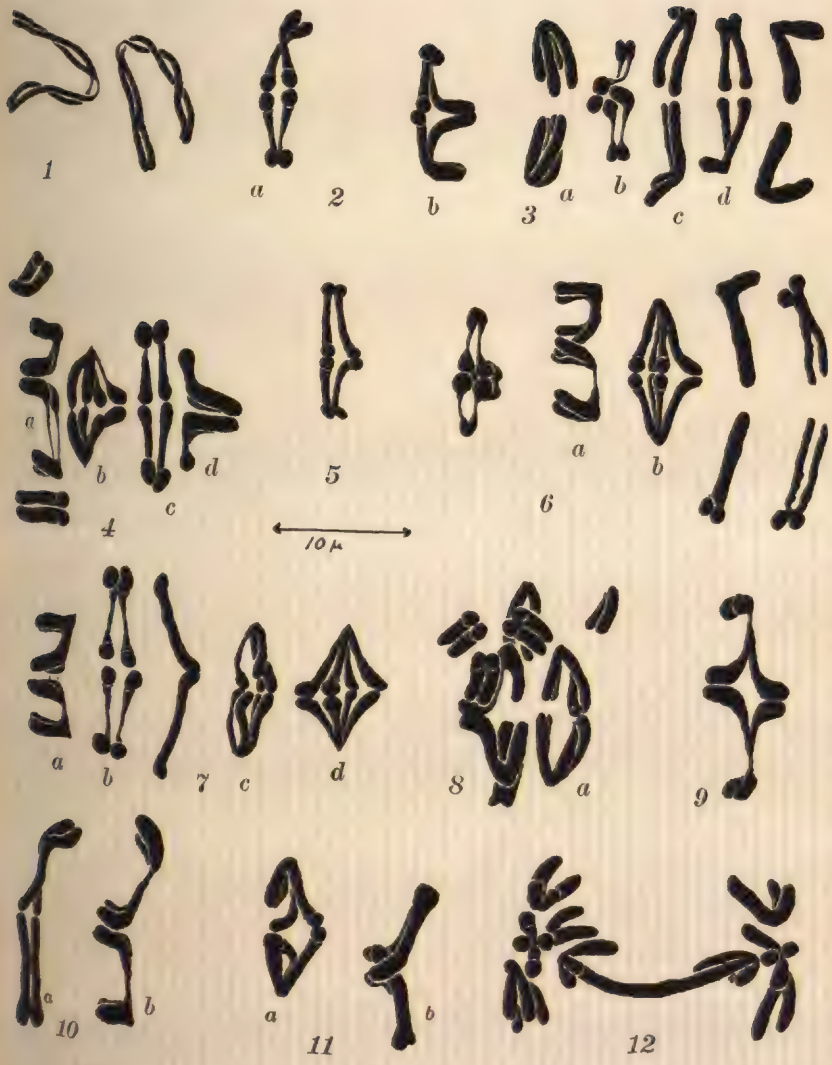
EXPLANATION OF PLATE 52

Figures of meiotic chromosomes are from smear preparations of pollen mother cells of *Pæonïa suffruticosa*, fixed with Navaschin's solution, and stained with crystal violet iodine.

Figure 1. Somatic chromosomes showing twisted chromatids at metaphase.
Figure 2. Types of chiasma formation at meiotic metaphase.
Figure 3. Early anaphase showing the five pairs of chromosomes.
Figure 4. Metaphase showing chromosome pairing without chiasma formation in chromosomes *a* and *d*.
Figure 5. Symmetrical arrangement of the chromatids.
Figure 6. Chromosome 6a has an asymmetrical chiasma of the type expected on Jannsens' partial chiasmatypy hypothesis. The symmetrical arrangement of the chromatids in chromosome 6b can not be reconciled with this hypothesis.
Figure 7. Chromosome pairing without chiasma formation (a) and two types of chromatid association (c and d).
Figure 8. Twisted chromatids in chromosome *a*. Four univalents at one pole—genetic "non-disjunction."
Figure 9. A type of chiasma formation rarely found in *Pæonia*.
Figure 10. Chromosome *a* shows a partial twist in sister chromatids. Evidence of stress in separating homologues of chromosome *b*, although no chiasma is present.
Figure 11. Symmetrical (a) and asymmetrical (b) chiasmata.
Figure 12. "Non-disjunction" of one pair of homologues and a persistent association of distal ends of "homologous" chromatids.



Meiosis and Chiasma Formation in Pæonia suffruticosa.

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ENUMERATION OF THE LIGNEOUS PLANTS COLLECTED BY J. F. ROCK ON THE ARNOLD ARBORETUM EXPEDITION TO NORTHWESTERN CHINA AND NORTHEASTERN TIBET

(ADDITIONS AND CONTINUATION)[1]

ALFRED REHDER AND CLARENCE E. KOBUSKI

Page 20 of vol. IX. insert before LILIACEAE:

GNETACEAE

Determined at the Botanical Museum, Berlin-Dahlem

Ephedra monosperma C. A. Meyer, Versuch. Monog. Ephedra, 89, t. 8, fig. 11. (1847).—Stapf in Denkschr. Math.-Nat. Cl. Akad. Wiss. Wien, LVI. pt. 2, p. 73, t. 3, fig. xix. 1–9, xxxi. 3 (Art. Ephedra) (1889)

EASTERN TIBET. Radja and Yellow River gorges: among schist rocky slopes of river valley, west of Radja, alt. 3350 m., no. 13939, May 27, 1926 (plant 5 cm. high; flowers yellow).

LILIACEAE

Page 20 insert before SMILAX TRACHYPODA Nort.:

Smilax Oldhamii Miquel in Versl. Med. Kon. Akad. Weten. ser. 2, II. 86 (1868); in Ann. Mus. Bot. Lugd.-Bat. III. 150 (1868).—Norton in Sargent, Pl. Wilson. III. 9 (1916).

CENTRAL KANSU: Lienhoa shan, no. 13664, Oct. 1925 (climber over bushes; fruit purplish black).

This species does not seem to have been recorded from China before.

Page 22 insert:

SALICACEAE

Populus L.

Determined by ALFRED REHDER

Populus cathayana Rehder in Jour. Arnold Arb. XII. 59 (1931). SOUTHWESTERN KANSU. Lower Tebbu country: banks

[1] See Vol. IX. 4–27, 37–125 (1928) for preceding parts of this Enumeration.

of Culungapu above Pezhu, no. 14961, Sept.–Oct. 1926 (pyramidal tree with broad crown, 15–18 m., leaf pale green above, grayish beneath).

Populus Simonii Carrière in Rev. Hort. 1867, p. 360.—Rehder in Jour. Arnold Arb. XII. 63 (1931).

Populus Przewalskii Maximowicz in Mél. Biol. XI. 321 (1881); in Bull. Acad. Sci. St. Pétersb. XXVII. 540 (1882).

SOUTHWESTERN KANSU. Tao River basin: Choni, along bank of Tao River, no. 12110, May 1925 (tree 15–18 m., pistillate); mountains of Choni, in forests and on banks of streams, alt. 3000 m., no. 12114, May 1925 (tree 20–24 m., staminate, catkins bright red).

Both specimens are leafless; the pistillate catkins are 2.5–3.5 cm. long with a short-pilose rhachis and short-pedicelled flowers; the ovary is slightly hairy and bears two stigmas.

Photographs representing habit and bark of this species and taken by Rock in January 1926 (no. 12110 according to his notes) are in his collection of photographs. In habit the trees resemble *Populus nigra* L.

Populus nigra Linnaeus, Spec. Pl. 1464 (1753).

NORTHWESTERN KANSU. Richthofen range and adjacent region: Kanchow plain, no. 13325, Nov. 1925 (tree 30 m. or more; trunk white).

I refer this specimen with some doubt to *P. nigra;* the branches are distinctly angular in their upper part, though perfectly terete in their lower third; the leaves are deltoid, truncate at the base, short-acuminate, and of firm subcoriaceous texture, and the bark of the trunk is white according to Rock.

Populus nigra L. var. **italica** Duroi, Harbk. Baumz. II. 141 (1772).

SOUTHWESTERN KANSU. Lower Tebbu country: banks of Peshwekiang, alt. 2000 m., no. 14859, Sept. 14, 1926 (tree 24 m., with ascending branches forming an oval to oblong crown; bark grayish white; leaves dark green above, blue green below).

According to Rock's note the tree has not the columnar habit of the Lombardy Poplar, but the branchlets of the specimen are distinctly adscending and the leaves agree with those of *P. nigra* var. *italica.*

Populus szechuanica Schneid. var. **Rockii,** var. nov.

A typo recedit foliis supra in costa et venis villoso-pilosis et subtus in costa, venis et venulis satis dense et in mesophyllo sparse pilosis.

SOUTHWESTERN KANSU. Lower Tebbu country: Wantsang forests, no. 14846, Sept. 12, 1926 (tree 30 m., trunk 1.25 in.

diam., without branches for 15 or 18 m.; bark drab to grayish brown, longitudinally furrowed; leaf grayish white beneath).

In shape and size of the leaf and in the 3–4-valved capsule the specimen agrees with *P. szechuanica*, but the under side of the leaf is fairly densely pilose on the midrib, veins and veinlets, and also on the upper side the veins are pubescent. In the latter character it resembles *P. Purdomii* Rehd., but that species has 2–3-valved capsules and somewhat narrower leaves glabrous above. It is possible, however, that the sterile specimens from Kagoba, Kansu, referred by me to *P. Purdomii*, belong here.

A picture showing the tall slender trunk of this tree is in the collection of Rock's photographs.

Salix L.[1]

Determined by R. Goerz

Sect. Pentandrae Dumortier

Salix paraplesia Schneider in Sargent, Pl. Wilson. III. 40 (1916).

Eastern Tibet. Radja and Yellow River gorges, with Spruces on northern slopes of valley south of Yellow River, opposite Radja, alt. 3200 m., no. 14111 ♂, June 10, 1926 (shrub to small tree 4.5–6 m.); southwest of Radja, alt. 3200 m., no. 13977 ♀, May 25, 1926 (shrub 2.4–3 m.); above Picea forest, southwest of Radja, alt. 3600 m., no. 13971, May 25, 1926 (shrub 1.2–1.5 m.); opposite Radja, alt. 3500 m., no. 13955 ♂, May 24, 1926 (shrub 1.5–2.4 m., leaf pale green).

Southwestern Szechuan (Muli): mountains of Kulu, alt. 3380 m., no. 17960 ♂, June 1929. (Shrub 1.5 m.)

The chief difference of this species from *S. pentandra* seems to lie in the whitish color of the under side of the leaves, which, however, is less conspicuous on young leaves and often nearly disappears, as on the plant from Szechuan. Other differences indicated by Schneider in his key (in Sargent, Pl. Wilson. III. 74), as size of catkins, number of stamens and length of style are probably less constant and therefore less important.

Sect. Sclerophyllae Schneider

Salix oritrepha Schneider in Sargent, Pl. Wilson. III. 113 (1916).

As Schneider knew only the pistillate plant the description of the staminate catkins may be given here:

Amenta coaetanea, pedunculo brevi 2–5 mm. longo foliis parvis 2–3 normalibus suffulto, ovata, 1–1.5 cm. longa, 0.8–1 cm. crassa,

[1] The Willows collected by Rock in southwestern Szechuan during 1928 and 1929 are included in this enumeration and are distinguished by smaller type.

densiflora; squamae late obovatae, semi-nigrae vel antice purpurascentes, utrinque basi inprimis crispo-villosae, dorso glabrescentes; nectaria 2, angusta, integra vel 2—pluries anguste lobata; stamina 2, filamentis liberis ½ pilosis, antheris ovatis aureis.

EASTERN TIBET. Alpine region between Radja and Jupar Range: alpine meadows of Wajo la, alt. 4200 m., no. 14154 ♂, June 1926 (shrub 60–90 cm.). Jupar Range: among rocks and alpine meadows, upper Jupar valley slopes, alt. 3600–3900 m., nos. 14294 ♂, 14295 ♀, 14296 ♂, 14297 ♀, 14298 ♀, 14299 ♂, 14300 ♀, 14301 ♂, June 1926 (shrub 0.60–1.20 m.); banks of upper Jupar stream, alt. 3600 m., nos. 14352 ♂, 14353 ♀, June 1926 (shrub 1.20–1.80 m.); valley slopes of Kerab, southern slopes of Jupar range, no. 14410 ♂, June 1926 (shrub 0.90–1.20 m.).

CENTRAL KANSU. Lien hoa shan: among rocks, alt. 3500 m. no. 12701 ♀, July 1925 (shrub 0.30–0.60 m.; leaves rich green above, glaucous beneath, male); alpine regions among Rhododendron scrub, alt. 3300 m., no. 12726 ♂, July 1925 (shrub 60–90 cm.; leaves dark green beneath); summit of mountain, alt. 3800 m., no. 13421 (fol.), Nov. 1925 (shrub 1.30 m. or less; semi-prostrate; buds red).

SOUTHWESTERN KANSU. Tao River basin: back of Adjuan, on ridges with Birch, Rhododendron and Spruce, alt. 3200–3300 m., no. 12655 ♀, July 5, 1925 (shrub 0.90–1.50 m.); mountains of Adjüan-Toyüku, Pakeshan, alt. 3000–3300 m., no. 13409 ♀, Nov. 1925 (shrub 1.20 m., forming dense bushes on limestone ridges; leaves pale yellowish beneath); mountains beyond Adjüan, Minshan, alt. 3450 m., no. 13414 (fol.), Nov. 1925 (shrub 0.90–1.20 m.; branches thick, reddish; leaves pale, yellowish beneath).

SOUTHWESTERN SZECHUAN (Muli): Mount Siga, northeast of Kulu, alt. 4600 m., no. 17883 ♂, June 1929 (shrub 60–90 cm.).

Salix oritrepha var. **tibetica** Goerz, var. nov.

Frutex humilis ad 1 m. altus, dense ramosus ramulis tenuioribus brevibus nodosis, foliis julisque minutis.

EASTERN TIBET. Radja and Yellow River gorges: rocky and grassy slopes above Picea forest, northern slopes of Yellow River, southwest of Radja, alt. 3600 m., no. 13969 ♂, May 25, 1926, nos. 13970 ♀, 13972, May 1926 (shrubs 0.60–1.20 m.); alpine meadows between Howa & Arh'tsa canyon, north of Radja, alt. 3450 m., no. 14040 ♂, May 31, 1926 (shrub 90 cm.); north of Radja, alpine slopes of Arh'tsa bluffs, alt. 3300 m., nos. 14053 ♂, 14054, May 31, 1925 (shrub 90 cm.).

SOUTHWESTERN SZECHUAN (Muli): Mount Mitzuga, west of Muli Gomba, alt. 3050–4875 m., no. 16036 ♂, June 1928 (semi-prostrate shrub); Mount Siga, northeast of Kulu, alt. 4300 m., no. 17874 ♀, June 1929 (shrub 0.90–1.20 m.).

(1295

Salix muliensis Goerz, spec. nov.

Frutex humilis v. ad 2 m. altus, ramosus ramulis brevibus nodosis, novellis breviter cinereo-tomentosis, postea glabrescentibus vel pilis brevibus obsitis opacis brunneis v. omnino sordide subatris; gemmae semiconicae, adpressae, brunneae, brevi-pilosae. Folia in petiolo 1–3 mm. longo, juvenilia (matura desunt) subtus pilis brevibus acroscopicis adpressis albo-sericeis tecta, dein glabrescentia, glauca, supra venis tantum pilosis mox glabra, atroviridia, elliptica v. obovato-elliptica, antice rotundata, nervis primariis 3–6, margine integro v. tenuissime glanduloso-denticulato; stipulae 0. Amenta (♂ tantum visa) coaetanea in pedunculo 2–3 mm. longo, bracteofoliis squamaceis v. crebrius foliolis normalibus suffulta, subglobosa vel ovata vel brevi-cylindrica, 5–16 mm. longa, 5–8 mm. crassa; squamae obovatae, semi-fuscatae, intus basi crispo-pilosae, dorso glabratae; nectaria bina v. dorsale 0, oblonga, ventrale paulo majus; stamina 2 filamentis liberis ½ pilosis, antheris subglobosis aureis.

Southwestern Szechuan (Muli): Mount Mitzuga, west of Muli Gomba, alt. 3050–4875 m., no. 16041 ♂ (shrub 2 m.), no. 16079 ♂, (shrub ½ m.), June 1928; Minya Konka Snow Range, south of Tatsienlu, alt. 4600 m., no. 17516 ♂, July 1929 (shrub 30–60 cm.).

This new species is near *S. oritrepha* Schneid., but differs chiefly in the pubescence of the young leaves. *Salix sclerophylla* Anders. from Kashmir shows, as far as I have seen material, a different, more woolly pubescence of the young leaves. The fine serration of the leaves lacking in the two other species, should also be noted.

Salix tenella Schneider in Bot. Gaz. LXIV. 137 (1917).—Handel-Mazzetti, Symb. Sin. VII. 68 (1929).

Southwestern Szechuan (Muli): Mount Mitzuga, west of Muli Gomba, alt. 3050–4875 m., no. 16035 ♀, June 1928 (shrub 2–3 m.); mountains of Kulu, alt. 4000 m., no. 17964 ♂, no. 17966 ♀, June 1929 (shrubs 1–1.5 m.).

The pubescence of the young leaves is the same in all three numbers and seems typical for the species. While the glaucous under surface is quite glabrous from the beginning or only slightly pubescent at the base, hairs are regularly present on the upper surface, though almost always restricted to the veins. It should also be noted that the young leaves after separation from the tip of the branch remains flat, while in the closely related *S. luctuosa* Lévl. they become strongly revolute at the margin.

Salix luctuosa × **tenella** Goerz, n. hybr.

Southwestern Szechuan (Muli): Mount Mitzuga, west of Muli Gomba, alt. 3050–4075 m., no. 16074 ♀, June 1928 (shrub 2 m.).

In its fruiting catkins this hybrid closely approaches *S. tenella* Schneid., but differs in its leaves which are strongly revolute along the margin when young and densely short-pubescent beneath. *Salix luctuosa* Lévl. and *S. tenella* seem to grow often together and there can be no doubt that hybrids between the two are not rare.

Sect. Eriostachyae Schneider

Salix Ernesti Schneider in Sargent, Pl. Wilson. III. 47 (1916).—Handel-Mazzetti, Symb. Sin. VII. 77 (1929).

Southwestern Kansu. Tao River basin: ridges of mountains west of Adjüan, alt. 3750 m., no. 12648 ♀, July 1925 (shrub 90 cm.); no. 12649 ♂, July 5, 1925 (shrub 90 cm.).

The pistillate plant also has a dorsal, though very small nectary. The young leaves are strongly revolute and only thinly pubescent and apparently quickly become glabrous.

Salix Balfouriana Schneider in Bot. Gaz. LXIV. 137 (1917).—Handel-Mazzetti in Symb. Sin. VII. 74 (1929).

SOUTHWESTERN SZECHUAN (Muli): Mount Mitzuga, west of Muli Gomba, alt. 3050–4875 m., no. 16070 ♀, June 1928 (tree 5 m.).

Salix plocotricha Schneider in Sargent, Pl. Wilson. III. 49 (1916).

? *Salix spathulifolia* Seemen in Bot. Jahrb. XXVI. Beibl. 82, p. 31 (1905).—Léveillé in Bull. Soc. Bot. France, LVI. 304 (1909).—Handel-Mazzetti, Symb. Sin. VII. 73 (1929).

SOUTHWESTERN KANSU. Tao River basin: along streams, near Adjüan, eastern Minshan, alt. 2700 m., nos. 12640 ♀, 12640a ♀, July 1925 (shrub 1.20–2.40 m.; leaves glaucous beneath); near the head of Maerkhu valley, alt. 3000 m., no. 12960 ♀, July 25, 1925 (tree 4.50–5.40 m.; leaves dark green; petioles and young shoots red; catkins reddish); near Tebbu, Shimen to Drjakana, alt. 3150 m., no. 13190 ♀, August 1925 (tree or shrub 1.80–3 m.; catkins long, greenish); Toyüku valley, slopes of Pakeshan, Minshan range, alt. 3000 m., no. 13410 (fol.), Nov. 1925 (shrub 4.50 m., branches slender; leaves dull beneath); beyond Adjüan, in forests along stream, alt. 3000 m., no. 13412 (fol.), Nov. 1925 (shrub or small tree 4.50–6 m., branches straw-colored); along banks of stream below Mt. Kuang kei, Kadjaku, Minshan, alt. 2850 m., no. 13415 (fol.), Nov. 1925 (shrub 1.80–3 m., branches ascending). Upper Tebbu country: along Kaichow stream not far from its source, south of the Minshan, alt. 3000 m., no. 12486 ♀, June 1925 (shrub 1.80–2.40 m.; leaf whitish below).

CENTRAL KANSU. Lien hoa shan: in Spruce forests and outskirts, alt. 3000 m., no. 12729 ♀, July 1925 (shrub 3 m., leaves glaucous beneath).

I was unable to decide whether Seemen's species is identical with *S. plocotricha*, since I could not examine the original. A close connection exists doubtless between the three species of the section Eriostachyae enumerated above. *Salix Ernesti* is distinguished from the other species chiefly by the presence of a second gland in the pistillate flower, a character which is not supposed to be constant. The specimens cited above for *S. Balfouriana* and *S. Ernesti* are very similar in the development of the leaves which are strongly revolute at first, but differ much in their pubescence, while in *S. plocotricha* the young leaves are flat and floccose-tomentose. Again similar to this is *S. Delavayana* Hand.-Mazz. which, however, has a glabrous ovary.

Sect. DENTICULATAE Schneider

Salix denticulata Andersson in Svensk. Akad. Hand. 1850, p. 481 (1851).—Klotzsch & Garcke, Bot. Ergeb. Reise Prinz. Waldemar, 119, t. 89 (1862).—Schneider in Sargent, Pl. Wilson. III. 117 (1916).

SOUTHWESTERN KANSU. Tao River basin: along lateral streams, Tao watershed, alt. 3000 m., no. 12237 ♂, June 1925 (shrub 1.80–3 m.; flowers yellow); along streams south of Minshan below Shimen, alt. 3000 m., no. 12484 ♂, June 1925 (shrub 1.50–2.40 m.).

Though this species originally described from the Himalayas has not yet been recorded from China, I have no doubt in its correct identification. The only difference would be the pubescence of the floral bracts which are described by Andersson as "obsolete puberulae," while they are on the Kansu specimens rather evenly short-pubescent. The two specimens though collected in different localities are very similar; in no. 12237 both nectaries are rather deeply divided into two narrow lobes.

Sect. LONGIFLORAE Schneider

Salix tibetica Goerz, spec. nov.

Frutex vel arbor ad 4.5 m. altus, ramulis novellis pubescentibus, anniculis omnino glabrescentibus, cortice gemmisque fuscis subinde parum pruinosis. Folia in petiolo puberulo 4–6 mm. longo, novella plana, utrinque glabra, costa supra brevi-tomentosiuscula subtusque parce pilosa excepta, adulta ovata vel ovato-elliptica, ca. (1:1¾) 3–4.5 cm. longa, basi rotundata, apice brevi vel triangulari, supra viridia, subtus glauca vel albida, margine sat dense crenato-dentata; stipulae 0 vel minutae, ovatae, deciduae. Amenta coaetanea, in pedunculo 2–6 mm. longo foliolis parvis 2–3 saepe caducis instructo, ♂ ovata, 1–1.5 cm. longa, 0.8 cm. crassa, densiflora, rhachi albo-pilosa; squamae ovatae, semifuscae, utrinque omnino basi crispo-pilosae; nectarium singulum ovale; stamina 2, filamentis liberis ⅓ pilosis 4–5 mm. longis, antheris ovalibus aureis. Amenta fructifera crasse cylindrica, densiflora, ca. 3 cm. longa, 1 cm. crassa, rhachi squamisque ut in ♂; nectarium singulum oblongum pedicellum glabrum 0.3–0.5 mm. longum subaequans; capsula glabra, ca. 4 mm. longa, stylo ca. 1 mm. longo stigmatibus 0.5 mm. longis bilaciniatis coronato.

EASTERN TIBET. Jupar Range: Jupar streambed, alt. 3150 m., no. 14304 ♂, June 1926 (tree 3.5–4.5 m.); Jupar valley along streambed, alt. 3150 m., no. 14284 ♀, June 1926 (shrub to tree 4.5 m.).

Salix juparica Goerz, spec. nov.

Frutex altus vel arbor ad 4.5 m. alta, ramulis tenuibus, novellis pubescentibus vel subglabris, demum omnino glabris, anniculis brunneis vel fuscis. Folia recentissima plana, subtus ab initio plus minusve glabra, supra dense pilosa cito glabrescentia, costa puber-

ula excepta, adulta in petiolo puberulo 2–4 mm. longo, elliptica (ca. 1.2) vel apicalia sublanceolata (1:2½–3) 3–4 cm. longa, utroque plus minusve aequaliter angustata, supra atroviridia, subtus glauca vel albido-glauca, margine crenulato vel interdum subintegro; stipulae 0 vel minutae, caducae. Amenta coaetanea, in pedunculo 0.4–0.8 cm. longo foliolis parvis vel squamaceis 2–3 instructo, ♂ cylindrica, ca. 2 cm. longa, 4–5 mm. crassa, densiflora, rhachi pilosa; squamae obovatae, pallidae, brevipilosae, ca. 1 mm. longae; nectarium singulum, oblongum; stamina filamentis 2 liberis ½ pilosis ca. 3 mm. longis, antheris subglobosis aureis. Amenta ♀ crasse cylindrica, ad 2.5 cm. longa, 9 mm. crassa, densiflora, fructifera ad 6 cm. longa, rhachi pilosa; squamae obovatae, semifuscae, puberulae, ca. 1 mm. longae; nectarium singulum oblongum, pedicellum ½ mm. longum plus minusve aequans; germen cinereo-pilosum ca. 5 mm. longum in stylum 0.5 mm. longum paulatim attenuatum, stigmatibus 0.5 mm. longis bilobatis plus minusve conniventibus.

EASTERN TIBET. Jupar Range: Jupar streambed, alt. 3150 m., no. 14303 ♀, June 1926 (tree 3.6–4.5 m.); Jupar valley along streambed, alt. 3150 m., no. 14283 ♀, June 1926 (tree 4.5 m.). Radja and Yellow River gorges: in streambed at Dachso canyon, north of Radja, alt. 3150 m., no. 14085 ♀, June 2 1926 (shrub 3–4.5 m.); northern slopes of river valley mountains opposite Radja, alt. 3150 m., no. 14001 ♂, May 27, 1926 (shrub 2.40–3 m.).

The specific differences between *S. juparica* and *S. tibetica* are not yet quite clear. The pistillate specimen of *S. tibetica* differs in the oval leaves and the glabrous capsules from the pistillate *S. juparica*. The staminate *S. tibetica* (no. 14304), however, also resembles *S. juparica* (no. 14303), together with which it apparently had been collected. It is not impossible that the latter is a hybrid. Further material is needed to arrive at a clear understanding.

Salix hypoleuca Seemen var. **kansuensis** Goerz, var. nov.

Differt a typo foliis subtus pallide viridibus (non glaucis), pedunculis foliis normalibus ceteris paulo minoribus instructo.

SOUTHWESTERN KANSU. Upper Tebbu country: south of Minshan range, along streams, alt. 2900 m., no. 12440 ♂, June 1925 (shrub or small tree 4.5 m.; catkins yellow); south of Minshan range near Tongwa, along streams, alt. 2900 m., no. 12441 ♀, June 1925 (shrub 1.80–2.40 m.); southern slopes of Minshan, along bank of mountain stream, alt. 3200 m., no. 12500 ♀, June 1925 (shrub 1.20–1.80 m.).

Salix Rockii Goerz, spec. nov.

Frutex ad 3 m. altus, ramulis sat longis saepe divaricatis, novellis pubescentibus, anniculis omnino glabris brunneis saepe subnitentibus; gemmae semiconicae, acutae, glabrae, nitidae. Folia juvenilia plana, subtus pilis longis acroscopicis sparse, supra pilis brevibus sparsissime obsita, mox glabra, subtus pallida vel subalbida, elliptica, ca. 1.5 cm. longa, margine minute denticulata, petiolo 1–2 mm. longo puberulo; folia matura desunt; stipulae 0. Amenta coaetanea, in pedunculo brevissimo 2 vel 3 foliolis vulgo sat magnis instructo, ♂ ovato-cylindrica, 2 cm. longa, 1 cm. crassa, densiflora, rhachi pilosa; squamae obovatae antice fuscatae, longe albo-barbatae; nectarium singulum (vel dorsale minutum) rectangulum; stamina 2 filamentis liberis ½ pilosis. Amenta ♀ crasse-cylindrica, 1.5–2 cm. longa, 8 mm. crassa, rhachi et squamis ut in ♂; squamae interdum pallidae; nectarium rectangulum pedicellum brevissimum subaequans; germen anguste conicum, 2 mm. longum, griseo-pilosum vel albo-tomentosum, in stylum 1 mm. longum fuscum attenuatum, stigmatibus 0.4 mm. longis plus minusve divisis divaricatis.

Eastern Tibet. Radja and Yellow River gorges: Radja gomba, on rocky cliffs with Junipers, alt. 3300 m., nos. 13928 ♂ and 13929 ♂, May 20, 1926 (shrub 2.40–3 m.); valley of Nyavruch north of Radja, lateral valley, along streambed, no. 13931 ♀, May 27, 1926 (shrub 1.20–1.80 m.); with Willows on rocky and grassy slopes above Yellow River gorge, alt. 3300 m., no. 13943 ♀, May 27, 1926 (shrub 1–1.20 m.); valley of Nyavruch northwest of Radja, and rocky streambed, alt. 3300 m., no. 13944 ♂, May 27, 1926 (shrub 2.40–3 m.); among spruce forest southwest of Yellow river opposite Radja, alt. 3450 m., no. 13957 ♀, May 24, 1926 (shrub 1.80 m.); same locality, alt. 3300 m., no. 13959 ♂, May 24, 1926 (shrub 2.40–3 m.).

This species resembles in its floral characters *S. oritrepha* Schneid., but differs clearly in its nectaries and in the finely serrate leaves.

Salix cereifolia Goerz, spec. nov.

Frutex ad 1.80 m. altus, ramulis sat tenuibus brevibus divaricatis, novellis sparse pubescentibus, anniculis glabris brunneis opacis vel sat nitentibus; gemmae glabrae, brunneae. Folia novella (adulta desunt) in petiolo brevi, plana, oblonga, utroque aequaliter angustata, ca. 1.5 cm. longa, utrinque glabra, supra viridia, subtus cereo obducto glauca, integra; stipulae 0. Amenta coaetanea, ♂ subsessilia, bracteofoliis squamaceis deciduis suffulta, anguste cylindrica, 1.5–2 cm. longa, 0.5 cm. crassa, densiflora, rhachi brevipilosa; squamae obovatae, pallidae, subglabrae; nectarium 1,

minutum, ovale; stamina 2, filamentis liberis glabris ca. 2 mm. longis squamas haud multo superantibus, antheris ovalibus aureis. Amenta ♀ tantum statu maxime juvenili adsunt, 5 mm. longa, simili figura ut in ♂ videntur; squamae glabrae, pallidae; nectarium 1, germen sessile, breviconicum, glabrum, stylo stigmatibusque brevibus.

SOUTHWESTERN KANSU. Tao River basin: mountains of Choni, in forests and banks of streams, alt. 3000 m., no. 12115 ♀, May 1925 (shrub 1.50–1.80 m.); mountains of Choni, alt. 2700 m., no. 12123 ♂, May 1925 (shrub 1.50–1.80 m.).

Resembles in its habit *S. tenella* Schneid., but differs in the staminate flowers having only one nectary and in the leaves being glabrous from the beginning.

Sect. DIPLODICTYAE Schneider

Salix Faxoniana Schneider in Bot. Gaz. LXIV. 143 (1917).—Handel-Mazzetti in Symb. Sin. VII. 82 (1929).

SOUTHWESTERN SZECHUAN (Muli): alpine meadows, Mount Mitzuga, west of Muli Gomba, alt. 4000 m., no. 16054 ♂, June 1928 (shrub 1 m.), mountains of Kulu, in gravelly streambed, alt. 4150 m., no. 17951 ♂, June 1929 (prostrate shrub).

The plants agree well with the male type of the species (Rock no. 4473) described by Handel-Mazzetti (l. c.).

Sect. BERBERIFOLIAE Schneider

Salix flabellaris Andersson in Svensk. Vetensk. Akad. Handl. 1850, p. 497 (1851); in Jour. Linn. Soc. IV. 54 (1860); in De Candolle, Prodr. XVI. pt. II. 295 (1868).—Schneider in Sargent, Pl. Wilson. III. 142 (1916).

SOUTHWESTERN KANSU. Upper Tebbu country: foot of Shimen, alt. 3600 m., no. 13059 ♀, July–August 1925 (prostrate shrub covering boulders and grassy slopes; catkins green).

SOUTHWESTERN SZECHUAN: Mount Konka, Risonquemba, Konkaling, alt. 3690–5335 m., no. 16869 ♀, June–August 1928 (prostrate shrub).

Salix flabellaris f. spathulata Andersson, l. c.

SOUTHWESTERN KANSU. Upper Tebbu country: foot of Shimen, alt. 3600 m., no. 13058 ♀, July–August 1925 (prostrate shrub growing perfectly flat, covering boulders and grassy slopes; catkins red).

Sect. LINDLEYANAE Schneider

Salix Lindleyana Wallich apud Andersson in Svensk. Vetensk. Akad. Handl. 1850, p. 499 (1851); in Jour. Linn. Soc. IV. 56 (1860); in De Candolle, Prodr. XVI. pt. II. 296 (1868).—Schneider in Sargent, Pl. Wilson. III. 145 (1916).

Salix Souliei Seemen in Fedde, Rep. Spec. Nov. III. 23 (1906).—Schneider in Sargent, Pl. Wilson. III. 62 (1916).

SOUTHWESTERN SZECHUAN (Muli): Mount Mitzuga, west of Muli Gomba, alt. 3050–4875 m., no. 16567 ♂, June 1928 (prostrate shrub); Minya Konka Snow Range, south of Tatsienlu, alt. 4660 m., no. 17529 ♂, July 1929 (prostrate shrub).

This apparently very polymorphous species is best to be compared with the European *S. retusa* L. The delimitation of the species united by Schneider under the section Lindleyanae is mostly rather uncertain and apparently further reductions will be necessary; shape and size of leaf, its margin and color of the under surface are often very variable in the same species, as it is the case in *S. retusa*.

Sect. GLAUCAE Fries

Salix opsimantha Schneider in Sargent, Pl. Wilson. III. 63 (1916).

SOUTHWESTERN SZECHUAN: Chiu-Lung-Hsien Territory, east of the Yalung River, alt. 3080 m., no. 16435 ♂, May 1929 (tree 3–5 m.; fls. rich pink with purplish tinge).

The plant agrees very well with Schneider's description. It resembles *S. Faxoniana*, as already stated by Handel-Mazzetti (Symb. Sin. VII. 82) but is readily distinguished by its tall habit, even tree-like in the specimen cited above.

Salix Ernesti × opsimantha Goerz, hybr. nov.

SOUTHWESTERN SZECHUAN: Mount Konka, Risonquemba, Konkaling, alt. 3960–5335 m., no. 16833 ♀, August 1928 (shrub 3–4 m.); Muli, mountains of Kulu, east of Muli Gomba, alt. 3650–4425 m., no. 16437 ♀, June 1928 (shrub 60–90 cm.).

No. 16833 differs from *S. opsimantha* Schneid. which it resembles according to Schneider's description, chiefly in the crenate leaves, the two nectaries (the ventral one twice as long as the dorsal one), entire or parted and in the tomentose fruit. The two latter characters indicate *S. Ernesti* as the second parent. No. 16437 is still closer to *S. opsimantha*, since it has only one long nectary and the ovary only slightly pubescent above the middle.

Salix pseudospissa Goerz, spec. nov.

Frutex 0.90–1.50 m. altus, ramulis brevibus crassis nodosis, novellis ab initio glabris, anniculis fuscis vel sordidis; gemmae semiconicae, adpressae, acutatae, argute carinatae, glaberrimae, fuscae. Folia in petiolo 3–6 mm. longo glabro, novella utrinque glaberrima (costa inclusa), plana, adulta obovata 3–5 cm. longa, apice brevi, basi rotundata, nervis primariis 8–10, reticulo utrinque obsolete elevato, supra atroviridia, subadiposa, subtus albida, margine anguste denticulato; stipulae 0. Amenta coaetanea, brevipedunculata, foliis 2–3 normalibus parvis suffulta, percrasse cylindrica, ad 3 × 1 cm. (fructu ad 5 cm.), rhachi crassa parce pilosa; squamae magnae (ad 2 × 6 mm.), obovatae, fuscae, venulosae, utrinque brevissime crispo-pilosae, dorso glabrescentes; nectarium singulum, oblongum, 0.6 mm. longum; stamina 2, ca. 12 mm. longa, filamentis liberis ½ pilosis, antheris ovatis flavidis. Amenta ♀ rhachi et squamis ut in ♂, squamis ex parte latioribus (3 mm.) antice saepe crenulatis; nectaria singula vel bina, ventrale ampullaceum, ad 0.8 mm., dorsale 0.5 mm. longum; pedicellus brevissimus nectarium dorsale aequans; germen anguste conicum, 3–4 mm. longum, squama occul-

tatum, subrufo-tomentosum, in stylum fuscum plus minusve 1.5 mm. longum maxima ex parte fissum attenuatum, stigmatibus 0.6 mm. longis bipartitis laciniis filiformibus erecto-patentibus.

SOUTHWESTERN KANSU. Tao River basin: Mt. Kuang ke shan, along mountain torrents, alt. 3600 m., no. 12362 ♀, June 1925 (shrub 1.2–1.5 m., catkins rich yellow); Minshan range, below pass of Mt. Kuang kei, alt. 3600 m., no. 12410 ♂, June 1925 (shrub 1.2 m. or less; flowers and catkins a rich yellow); Mt. Kuang Kei, trail to Djrakana, Minshan, among Rhododendron, alt. 3750 m., no. 13414 (fol.), Nov. 1925 (shrub 1.2–1.5 m.; branches stiff, thick; leaves pale beneath).

CENTRAL KANSU. Lien hoa shan: alpine regions; alt. 3300 m., no. 12725, July 1925 (shrub 1.5 m., leaves glaucous beneath).

This species differs from *S. spissa* Anderss. found in the Tienshan and Altai Mountains chiefly in the large less pubescent floral bracts and the partly double nectary. It is to be expected that occasionally also in the staminate flower a dorsal nectary may occur. Also the very close serrature and the perfectly glabrous branches of leaves should be noted.

Salix Delavayana Handel-Mazzetti in Symb. Sin. VII. 78 (1929).

SOUTHWESTERN SZECHUAN (Muli): mountains south of Muli, Mount Gibboh, alt. 3050–3960 m., no. 17238 ♂, May 1928 (shrub 2–3 m.); mountains of Kulu; alt. 4000–4300 m., no. 17952 ♂, no. 17953 ♀, no. 17965 ♂, no. 18095 ♂, June–July 1929 (shrub 0.60–1.50 m.).

Those numbers in which the catkins and leaves are just expanding, show much resemblance to *S. spodiophylla* Hand.-Mazz. (op. cit. 77), which is possibly a hybrid with *S. Delavayana* as one of the parents.

Sect. CAPREAE Dumortier

Salix Wallichiana Andersson in Svensk. Vetensk. Akad. Handl. 1850, p. 477 (1851); in Jour. Linn. Soc. IV. 50 (1860); in Svensk. Vetensk. Akad. Handl. IV. 80, tab. 5, fig. 46 (Monog. Salic.) (1867); in De Candolle, Prodr. XVI. pt. II. 223 (1868).—Schneider in Sargent, Pl. Wilson. III. 64 (1916).—Handel-Mazzetti, Symb. Sin. VII. 87 (1929).

SOUTHERN KANSU: mountains of Pikou and Mosuping, alt. 1200 m., no. 12066 ♂, April 1925 (shrub 1.5–1.8 m.).

SOUTHWESTERN KANSU. Tao River basin: mountains of Choni, west of Tao river, Picea forest, alt. 3000–3150 m., no. 12125 ♀, no. 12126 ♂, no. 12128 ♂, May 1925 (tree 4.50–5.40 m.); Choni, banks of mountain streams west of Taoho, alt. 2850 m., no. 12135 ♀, May 1925 (shrub 1.5 m.); mountains west of Choni, alt. 3000 m., no. 12136 ♂, May 1925 (shrub or small tree 4.5 m.); along banks of Choni river, near bridge, alt. 2520 m., no. 12305 ♀, June 1925 (tree 4.5–6 m., often shrubby).

WESTERN SZECHUAN: above Ching chuan mountains along stream, alt. 1800 m., nos. 12045 ♀, no. 12047 ♂, no. 12048 ♂, April 1925 (tree or shrub 1.80–3 m.).

Salix pseudo-Wallichiana Goerz, spec. nov.

Frutex excelsus vel arbor ad 6 m. alta, ramulis sat tenuibus novellis pubescentibus vel albo-villosulis, anniculis, subglabris brunneis vel fuscis; gemmae conicae, brunneae, glabrae. Folia in petiolo puberulo 4–6 mm. longo, utrinque pilis brevibus adpressis sparse obducta, plana, adulta glabra vel costa puberula, late ovato-elliptica, apice brevi (1:1½–2), apicalia ovato- vel obovato-lanceolata, apice subproducto (ca. 1:3), 3–5 cm. longa, supra opaco-viridia, subtus glauca, nervis primariis 7–10, reticulo vix conspicuo subtus parum elevato, margine integro vel in foliis apicalibus irregulariter dentato. Stipulae 0 vel parvae, semicordatae. Amenta coaetanea vel subcoaetanea in pedunculo brevissimo vel in ♀ ad 7 mm. longo, bracteis squamaceis caducis suffulta, ♂ ovata, ca. 2 cm. longa, 1.5 cm. crassa, densiflora, rhachi pilosa; squamae anguste obovatae, ca. 0.6 × 1.8 mm., antice subatrae, longe albo-barbatae; nectarium oblongum, 0.5 mm. longum; stamina filamentis 2 liberis ½ pilosis, 6 mm. longis, antheris ovalibus aureis. Amenta ♀ crasse cylindrica, ad 3.5 cm. longa, 1.5 cm. crassa, densiflora; squamae et nectarium ut in ♂; pedicellus nectarium aequans vel triplo superans, pilosus; germen anguste conicum, 4.5 mm. longum, stylo 0.4–0.6 mm. longo, stigmatibus 0.6 mm. longis, divisis, laciniis tenuibus, patentibus. Valvae capsulae post dehiscentiam parum recurvatae.

EASTERN TIBET. Grasslands between Labrang and Yellow River: in Serchen leading to Yellow River between Dzangar and Radja Gomba, no. 13917 ♂, May 15, 1926 (shrub 3–4.5 m., flowers golden yellow). Jupar Range: streambed of Jupar valley, alt. 3150 m., no. 14287 ♀, June 1926 (tree 4.5–6 m.). Radja and Yellow River gorges: along streambed and outskirts of spruce forest in Dachso Canyon, north of Radja, alt. 3150 m., no. 14077 ♀, June 2, 1926 (shrub 3 m.).

The catkins and all parts of the flower are more graceful than in *S. Wallichiana* Anderss., the filaments are pubescent, the pedicel short or very short, the style longer and the leaves broader. The latter resemble much the type of *S. livida* Wahlbg. which, however, has very long pedicels. One could almost take these plants for hybrids of *S. Wallichiana* with *S. Rockii* Goerz, but the former has not been collected in Eastern Tibet by Rock or by any one else.

Sect. INCUBACEAE Dumortier

Salix sibirica Pallas, Fl. Ross. I. pt. II. 72, t. 81, fig. 3 (1788).—Schneider in Sargent, Pl. Wilson. III. 154 (1916).

EASTERN TIBET. Radja and Yellow River gorges: valley of Nyavruch north of Radja, lateral valley, along rocky streambed, no. 13932 ♂, May 27, 1926 (shrub 1.8–2.4 m.).

SOUTHERN KANSU: mountains of Motzuping and Pikou, along stream, no. 12071 ♂, April 1925 (shrub 1.2 m.).

SOUTHWESTERN KANSU. Tao River basin: Minshan range, ravines of Kadjaku, alt. 3150 m., no. 12379 ♂, June 1925 (shrub 2.4–3 m.); Minshan range, slopes of Kadjaku valley below Kuang ke, alt. 3000 m., no. 12420 ♂, June 1925 (shrub 3 m.; catkins yellow).

CENTRAL KANSU. Lien hoa shan: swampy alpine meadows, alt. 2850–3000 m., no. 12685 ♀, July 14–20, 1925 (shrub 60–90 cm., often 30 cm.; leaves silvery), no. 13420 (fol.), Nov. 1925 (shrub 1.2–1.8 m.; leaves silvery tomentose on both sides).

Salix sibirica is new for China; the specimens, however, are not all typical. Very characteristic is the pistillate plant from central Kansu which could even be taken for the European *S. repens* L., if it had longer pedicels. On account of its short pedicels it belongs to var. *subsessilis* (Regel) Goerz (*S. repens* var. *subsessilis* Regel). The two numbers from southwestern Kansu recall forms from the Pamir which constitute a distinct species (*S. schugnanica* Goerz, adhuc ined.), but are not identical with it. Owing to the lack of fully grown leaves a definite conclusion cannot be reached. The filaments are glabrous in all numbers.

Salix juparica × sibirica Goerz, hybr. nov.

EASTERN TIBET. Radja and Yellow River gorges: valley of Nyavruch north of Radja, lateral valley, along rocky streambed, no. 13933 ♂, May 1926 (shrub 3–4.5 m. branching from base; flowers yellow).

This hybrid was found at the locality cited with both parents. It resembles *S. sibirica* Pall., but differs in the somewhat slenderer catkins, the slightly pubescent filaments and in the scarcely pubescent unfolding leaves.

Sect. VIMINALES Bluff & Fingerhuth

Salix Rehderiana Schneider in Sargent, Pl. Wilson. III. 66 (1916).

SOUTHERN KANSU: mountains between Motzuping and Pikou, along streambeds, no 12070 ♀, April 1925 (shrub 1.5–1.8 m.).

The catkins of the specimen are still very young, but according to the floral characters (pedicel and ovary glabrous; style long, stigmas short, pedicel very short) it can hardly be referred to any other species.

Salix Rehderiana Schneid. var. **brevisericea** Schneider l. c. 67.

EASTERN TIBET. Grasslands between Labrang and Yellow River: Gochen valley near mouth at Yellow River gorge south of Dzang lamassery, alt. 3060 m., (?) no. 13912 ♀, May 14, 1926 (shrub 1.6–2.4 m.). Radja and Yellow River gorges: rocky slopes back of Radja, alt. 3300 m., (?) no. 13925 ♂, May 20, 1926 (shrub 1.6–2.4 m.); valley of Nyavruch north of Radja, lateral valley, along rocky streambeds, no. 13934 ♀, May 27, 1926 (shrub 2.4–3 m.). Jupar Range: Jupar streambed, alt. 3150 m., nos. 14305 ♀, and 14306 ♂, June 1926 (tree 3–4.5 m.); along streambed in upper Jupar valley, alt. 3600 m., no. 14350 ♀, June 1926 (shrub 3–3.6 m.).

SOUTHWESTERN KANSU. Upper Tebbu country: along banks of mountain streams, southern slopes of Minshan, alt. 3180 m., no. 12501 ♀, June 1925 (shrub 1.8–2.4 m.). Tao River basin: forests of Shiaoku, among Larches, Birches, Spruce, alt. 3000 m., no. 12816 ♀, July 1925 (shrub 2.4–3.6 m.). Lower Tebbu country: along stream of Mayaku in Abies forest, alt. 3000 m., no. 14962 (fol.), Oct. 1926 (shrub 3–4.5 m., with ascending branches; leaf dull green above, pale beneath).

CENTRAL KANSU. Lien hoa shan: among alpine scrub and on edge of forests, alt. 3450 m., no. 12785 ♀, July 1925 (shrub 1.2 m.); same locality alt. 2850 m., no. 13419 (fol.), Nov. 1925 (shrub 1.8–2.4 m., branches blackish; leaves dark green, glossy above, glaucous beneath).

The variety with pubescent ovary seems to be the most common in the region. No. 13934 resembles very much the plant distributed under no. 644 by Toepffer in his Salices exsiccatae. I cannot see any evidence of a relationship between var. *brevisericea* and *S. myrtillacea*, as suggested by Schneider (l. c.). Nevertheless one of the two forms, the one with glabrous or the one with pubescent ovary may turn out to be a hybrid. No. 13925 has its buds just opening and therefore its identification is not quite certain. No. 13925 may possibly be a hybrid of *S. Rehderiana* and × *S. taoensis* Goerz as the thicker very precocious catkins suggest.

Sect. HELIX Dumortier

Salix Wilhelmsiana Marshall von Bieberstein, Fl. Taur.-Caus. III. Suppl. 627 (1819).—Schneider in Sargent, Pl. Wilson. III. 169. (1916).—Fedtschenko, Consp. Fl. Turk. VI. 326. (1916).—Goerz in Grossheim, Fl. Kauk. II. 10 (1930); in Fedde, Rep. Spec. Nov. XXVIII. 129 (1930); Salic. Asiat. I. 16, no. 17 (1931).

Salix angustifolia Willdenow, Sp. Pl. IV. 699. (1805).—Stschégléew in Bull. Soc. Nat. Moscou, XXVII. pt. I. 196 (1854).—Boissier, Fl. Orient. IV. 1187 (1879).

Salix angustifolia var. *eriocarpa* Ledebour, Fl. Ross. III. 604 (1850).
Salix dracunculifolia Boissier in Kotschy, Pl. Pers. austr. no. 621; Diagn. I. 99 (1846).—Boissier et Buhse, Herb. Pers. I. 201, sec. Andersson.—Trautvetter in Act. Hort. Petrop. IX. 176 (1884).

EASTERN TIBET. Radja and Yellow River gorges: valley of Nyavruch, north of Radja, lateral valley, along streambed, nos. 13936 ♀ and 13937 ♂, May 27, 1926 (shrub 1.20 m.); north of Radja, Yellow River valley, alt. 3150 m., nos. 14031 ♀ and 14032 ♂, May 28, 1926 (shrub 1.20–1.80 m.). Ba valley: along stream, alt. 3000 m., no. 14262 ♀, June 1926.

SOUTHWESTERN KANSU. Tao River basin: Choni, banks of Tao river, alt. 2460 m., no. 12107 ♂, May 1925.

The specimen from Tibet agrees with the type of the species, only 13936 has somewhat longer styles, possibly due to the influence of *S. myrtillacea*. The specimen from Kansu is not yet sufficiently developed but seems to belong also to the type.

Salix cheilophila Schneider in Sargent, Pl. Wilson. III. 69 (1916).—Handel-Mazzetti, Symb. Sin. VII. 87 (1929).

SOUTHWESTERN SZECHUAN (Muli): Muli and Litang River valley, near Muli Gomba, alt. 2600–3000 m., no. 16119 ♀, May 1928 (shrub or small tree).

Salix myrtillacea Andersson in Jour. Linn. Soc. IV. 51 (1860).—Schneider in Sargent, Pl. Wilson. III. 71 (1916).—Handel-Mazzetti in Symb. Sin. VII. 89 (1929).

Salix subpycnostachya Burkill in Jour. Linn. Soc. XXVI. 532 (1899).—Léveillé in Bull. Soc. Bot. France, LVI. 301 (1909).
Salix squarrosa Schneider in Bot. Gaz. LXIV. 142 (1917).

EASTERN TIBET. Radja and Yellow River gorges: rocky slopes back of Radja, alt. 3300 m., no. 13927 ♂, May 20, 1927 (shrub 1.80–2.40 m.); rocky and grassy slopes above Picea forest, northern slopes Yellow River southwest of Radja, alt. 3600 m., no. 13967 ♂, May 25, 1926 (shrub 0.60–1 m.); alpine regions south of river, opposite Radja, alt. 3600 m., no. 13997 ♀, May 27, 1926 (shrub 1–1.2 m.); valley of Nyavruch north of Radja, alt. 3300 m., no. 14039 ♂, May 31, 1926 (shrub 1.20–1.50 m.).

SOUTHWESTERN KANSU. Tao River basin: mountains west of Choni, alt. 3000 m., no. 12137 ♂, May 1925 (shrub 60–90 cm.; flowers red as is the whole plant); Minshan range, southwest of Choni on slopes and alpine meadows, alt. 3300 m., no. 12359 ♂, June 1925 (shrub 0.90–1.20 m.; catkins grey); ravines of Kwadjaku, alt. 3150 m., no. 12378 ♀, June 1925 (shrub 1.50–1.80 m.); along river, near Choni, no. 13402 (fol.), Nov. 1925 (shrub or small tree 2.10–3 m.); valley of Maerhku, Minshan range, alt. 2700 m., no. 13407 (fol.), Nov. 1925 (shrub 1.50–2.40 m.; much branched, leaves white beneath), no. 13408 (fol.), Nov. 1925 (shrub 1.20–1.80 m., much branched; leaves green beneath); among rocks and alpine

meadows, Toyüku, Minshan, Pakeshan, alt. 3450 m., no. 13411 (fol.), Nov. 1925 (shrub 90 cm., compact). Upper Tebbu country: Djrakana, southwest of Minshan, outskirts of Abies forest, alt. 3000 m., no. 13417 (fol.), Nov. 1925 (shrub 1.80–2.40 m., branches bronze color; leaves papery, glaucous beneath), no. 13418 (fol.), Nov. 1925 (shrub 1.50–1.80 m.; leaves glaucous beneath).

Southwestern Szechuan (Muli): mountains south of Muli, Mount Gibboh, alt. 3050–3960 m., no. 16823 ♀, May 1928 (shrub 2–3 m.); Mount Mitzuga, west of Muli Gomba, alt. 3050–4875 m., no. 16096 ♀, June 1928 (shrub 1–2 m.); Minya Konka Snow Range, south of Tatsienlu, alt. 4600 m., no. 17526 ♀, July 1929; Mount Siga, northeast of Kulu, alt. 4300–4450 m., no. 17887 ♀, June 1929 (shrub 1.50 m.), no. 17889 ♂ (shrub 0.90–1.20 m.).

The specimens from Szechuan are generally more vigorous and have larger and thicker catkins than those from Kansu and Eastern Tibet, but do not differ otherwise. The sometimes peculiar habit which induced Schneider to propose *S. squarrosa* as a distinct species, is seen also in Tibetan specimens (e. g. no. 13927). It is probably only a monstrosity and may be due to injuries by grazing animals, insects or climate. Some of the numbers cited show perhaps traces of hybridization, particularly with *S. Wilhelmsiana*, but it is hardly possible to give a more exact interpretation of these forms lacking either leaves or flowers.

Salix myrtillacea × Wilhelmsiana (S. taoensis) Goerz, hybr. nov.

Eastern Tibet. Grasslands between Labrang and Yellow River: Gochen valley near mouth at Yellow River, south of Dzangar lamassery, alt. 3060 m., nos. 13909 ♂, and 13911 ♀, May 14, 1926 (shrub 3 m.); rocky gorge of Serchen leading to Yellow River gorge, southeast of Radja, alt. 3120 m., no. 13915 ♂, May 14, 1926 (shrub 2.40–3 m.). Radja and Yellow River gorges: rocky slopes back of Radja Gomba, alt. 3300 m., no. 13921 ♂, May 20, 1926 (shrub 3 m., branching from near base); valley of Nyavruch north of Radja, lateral valley, along rocky streambed, no. 13930 ♀, May 27, 1926 (shrub 1.80–2.40 m.); north of Radja, Yellow river valley, alt. 3150 m., no. 14033 ♀, May 28, 1926 (shrub 3–3.6 m.).

Southwestern Kansu. Tao River basin: forest of Choni, along Tao river, no. 12099 ♂, May 1925 (shrub 2.40–3 m.); Choni, banks of Tao river, alt. 8200 m., May 1925, nos. 12103 ♂ (shrub 1.5 m.), 12104 ♂ (shrub 1.2 m.) and 12105 ♀ (shrub 1.5–1.8 m.); mountains of Choni, Picea forest outskirts, alt. 2700 m., no. 12106 ♀, May 1925 (shrub 1.8–2.4 m.); southern bank, Choni, no. 12265 ♀, June 1925 (shrub 1.5–1.8 m.). Minshan range: in ravines of Kadjaku, alt. 3150 m., no. 12377 ♀, June 1925 (shrub 1.8–3 m.; catkins small grey); Choni, alt. 2550 m.,

Nov. 1925, nos. 13401 (fol.) (shrub 1.5 m., much branching), 13403 (ram.) (shrub 1.5–2.4 m., branches red, branchlets pubescent), 13404 (fol.) (shrub 1.5–2.4 m., branches red, pubescent; leaves pubescent on both sides), 13405 (fol.) (shrub 1.2–1.5 m., branches dark red, leaves white beneath) and 13406 (fol.) (shrub 2.4–3 m., branches green); Kadjaku, along stream, alt. 2240 m., no. 13416 (fol.), Nov. 1925 (shrub 1.5–1.8 m., branches stiff, blackish; leaves green beneath). Lower Tebbu country: along stream near Nyiba, alt. 2550 m., no. 14963 (fol.), Oct. 1926 (shrub 3–4.5 m.; leaves bluish grey beneath).

This hybrid is in localities where the two parent species occur, apparently not only very frequent, but also exceedingly polymorphous. On account of the incompleteness of the material it is not always possible to draw the lines between them and the parents. One may assume that the hybrid is fertile and that by recrossing with the parent the limits become indistinct. Thus e. g. no. 12105 is very near *S. Wilhelmsiana* and also no. 13911 with its slender catkins may represent a recrossing with *S. Wilhelmsiana*, while others might be interpreted as forms of *S. myrtillacea*. Not rare seems to be a combination of the staminate catkins which resembles those of the European *S. purpurea* (e. g. nos. 12099 and 12103) or those of its Caucasian variety *virescens* Anders. (no. 12104). Likewise the shape of the leaves changes from narrow-oblanceolate to narrow obovate. No. 14963 has leaves resembling those of *S. tenuijulis* Ledeb. which ranges from the Tianshan to Armenia; the leaves, however, differ from that species not only slightly in the serration, owing to the influence of *S. Wilhelmsiana*, but also lack completely the stipules which are so characteristic for *S. tenuijulis*. Besides the leaves are in October still furnished on both sides with the long acroscopic hairs of *S. Wilhelmsiana*. No. 12265 represents a somewhat intermediate leaf shape, broad-lanceolate to oblanceolate with short point; the serration extends here in contrast to *S. myrtillacea* almost to the base and the pubescence is lacking entirely on the mature leaves. The hybrids show also in habit an intermediate character. While *S. Wilhelmsiana* generally attains only a height of 1.6 m., *S. myrtillacea* grows into a shrub up to 4 in. tall. Among the hybrids shrubs up to 3 m. are found.

Salix myrtillacea × Rockii Goerz, hybr. nov.

Eastern Tibet. Radja and Yellow River gorges: alt. 3150 m., no. 13953 ♂, May 25, 1926 (shrub 2.4–3 m.); with Spruces on northern slopes of valley south of Yellow River, opposite Radja, alt. 3150 m., no. 14112 ♀, June 10, 1926. Jupar Range:

along streambed in upper Jupar valley, alt. 3600 m., no. 14349 ♀, 1926 (shrub 1.8–2.4 m.).

In the male plant the filaments are mostly connate and besides often villous up to the apex. Nos. 14112 and 14349 have well developed leaves which are about intermediate between the parents; they are densely denticulate almost to the base. In no. 13112 the longer, parted and somewhat spreading stigmas indicate the influence of *S. Rockii*. In no. 14349 perhaps *S. Wilhelmsiana* is involved besides *S. Rockii*, as suggested by the comparatively small fruiting catkins.

Salix Delavayana × **myrtillacea** Goerz, hybr. nov.

Southwestern Szechuan (Muli): Mount Mitzuga, west of Muli Gomba, alt. 3050–4875 m., no. 16038 ♂, June 1928 (shrub 2 m.).

This Willow resembles *S. Delavayana* but differs chiefly in the lack of the dorsal nectary (the ventral one being nearly 1 mm. long) and the mostly ¼–⅓ connate filaments. The floral bracts are long and densely bearded. Perhaps *S. spodiophylla* Hand.-Mazz. belongs partly to this hybrid.

Sect. INCERTA

Salix Alfredi Goerz, spec. nov.

Frutex vel arbor ad 4.5 m. alta, ramulis tenuibus, recentissimis laxe pilosis citissime glabris, anniculis vetustioribusque brunneis vel fuscis, opacis vel rarius nitidulis; gemmae semiconicae, obtusae, glabrae, brunneae. Folia in petiolo piloso 3–5 mm. longo, recentissima plana, utrinque laxe sericea (subtus pilis longis laxis acroscopicis, supra pilis brevioribus), postea utrinque glabrescentia (costa ventrali, ut videtur, persistentius puberula), ovato-lanceolata, ca. 1:2½, basi rotundata, apice plus minusve triangulari, supra opace viridia, subtus pallide vel caesio-glauca, integra; stipulae 0. Amenta (♀ tantum nota) coaetanea, subsessilia, bracteis minutis caducis suffulta, anguste cylindrica, gracilia, 3–4 cm. longa, 2–3 mm. crassa, postea ad 5.5 cm. longa, 6 mm. crassa, laxiflora, rhachi albohirsuta; squamae obovatae, ca. 0.7 × 1 mm., subbrunneae, utrinque dense sat breviter albo- vel subrufo-hirsutae; nectarium ventrale minutum (0.3–0.4 mm. longum), oblongum, dorsale; pedicellus brevissimus (brevior quam nectarium) vel nullus; germen minutum (ca. 1 mm. longum), conicum, acutatum, breviter albo-pilosum, stylo subnullo, stigmatibus 0.2 mm. longis plus minusve lobatis divaricatis vel suberectis; capsula ad 2 mm. longa, parcius pilosa.

Southwestern Kansu. Tao River basin: mountains of Choni, west of Taoho, alt. 3000 m., May 1925, nos. 12147 (fol.) (shrub 1.5–2.4 m.), 12149 ♀ (shrub 2.4–3 m., outskirts of Picea forest). Upper Tebbu country: in limestone gorges en route to Tebbu land, southern slopes of Minshan, alt. 3300 m., no. 12522 ♀, June 1925 (shrub or small bushy compact tree 4.5 m.).

Nearest to this graceful Willow in habit is perhaps *S. hylonoma* Schneid., which differs in the denticulate leaves, the dense-flowered catkins, the long narrow nectary, the parted style and, as it seems, also in the larger size of all its parts. The young catkins of *S. Alfredi* are also similar in appearance to those of *S. heterochroma* Seemen, but also these are dense-flowered and have entirely different styles and stigmas and besides longer pedicels. Owing to the lack of staminate flowers, it does not seem possible to refer this new species to any of the sections.

The species is named in honor of Alfred Rehder, Curator of the Herbarium of the Arnold Arboretum.

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POLYGONACEAE

Polygonum Auberti L. Henry.—Add the following number:

SOUTHWESTERN KANSU. Tao River basin: along stream between Taochow and Kan-ku, alt. 2450 m., no. 13210, Aug. 1925 (huge climber forming dense masses; flowers cream-colored).

Page 39

RANUNCULACEAE

Clematis aethusifolia Turcz.—Add the following no.:

CENTRAL KANSU. Lien hoa shan: alt. 2750 m., no. 12753, July 14–20, 1925 (climber; flowers yellow, sepals with cream-colored margins).

Page 41.

Clematis brevicaudata DC.—Add the following no.:

CENTRAL KANSU. Lien hoa shan: along bank and over shrubs, alt. 2750 m., no. 12750, July 14–20, 1925 (climber, flowers cream-colored).

Page 42.

Clematis glauca var. **akebioides** f. **phaeantha** Rehd.—Add the following no.:

CENTRAL KANSU. Lien hoa shan: beyond Yitao, loessy slopes, alt. 1500 m., no. 13228, Aug. 1925 (climber; flowers purplish-brown).

Clematis tangutica var. **obtusiuscula** Rehder & Wilson.—Add the following no.:

SOUTHWESTERN KANSU. Tao River basin: around Choni, alt. 2600 m., no. 12917, July 1925 (forming large straggling scandent bushes, common; flowers brownish yellow).

SAXIFRAGACEAE

Page 51.

Hydrangea Bretschneideri Dippel.—Add the following no.:

SOUTHWESTERN KANSU. Tao River basin: below Choni, along shady banks of Tao River, alt. 2500 m., no. 12228, June 1925 (flowers white).

ROSACEAE

Page 72.

Rubus idaeus var. **strigosus** Maxim.—Add the following no.:

EASTERN TIBET. Radja and Yellow River gorges: spruce forests, northern slopes of River valley; south of Radja, no. 13986, May 25, 1926 (flowers white).

LEGUMINOSAE

Page 84.

Hedysarum multijugum Maxim.—Add the following nos.:

EASTERN TIBET. Radja and Yellow River gorges: grassy northern banks of river near Radja, alt. 3000 m., no. 14002, May 27, 1926 (flowers purple). Ba valley: on loess bluffs, alt. 3000 m., no. 14244, June 1926; on loess bluffs and banks of lateral ravines of valley, alt. 2850 m., no. 14363, July 1926.

ERICACEAE

Page 106.

Rhododendron rufum Batal.—Add the following no.:

SOUTHWESTERN KANSU. Tao River basin: Maerkhu valley north of Minshan, Abies and Picea forest, alt. 3200–3350 m., no. 13675, Sept.–Oct. 1925 (in fruit; flowers pink).

VERBENACEAE

Page 112.

Caryopteris incana Miquel. . . .
Caryopteris Mastacanthus Schauer. . . .
Change to:

Caryopteris tangutica Maximowicz in Bull. Acad. Sci. St. Pétersb. XXVII. 525 (1881); in Mél. Biol. XI. 301 (1881).—P'ei in Mem. Sci. Soc. China, I. no. 3, p. 172 (Verbenac. China) (1932).

A specimen collected by Purdom (no. 792) in the Taochow District also belongs here. The two numbers of the Rock collection cited by P'ei as nos. 12709 and 12755 are mistakes for no. 12765.

CAPRIFOLIACEAE

Page 120.

Lonicera microphylla Willdenow.—Add no. 14070 to the last specimen cited as "three days north of Radja, alt. 3350 m."

COMPOSITAE

Determined by J. MATTFELD

Aster incisus Fischer in Mém. Soc. Nat. Moscou, III. 76 (1812).—Hemsley in Jour. Linn. Soc. Bot. XXIII. 412 (1888).

SOUTHWESTERN KANSU. Lower Tebbu country: gravelly rocky banks of Peshwekiang, alt. 2000 m., no. 14556, Aug. 30, 1926 (shrub 60–90 cm.; flowers white).

Aster Limprichtii Diels in Fedde, Rep. Spec. Nov. Beih. XII. 503 (Bot. Reis. Hochgeb. Chin. Ost-Tib.) (1922).

SOUTHWESTERN KANSU. Lower Tebbu country: Oak forest near Nyipa village, Mayaku, alt. 2300 m., no. 14803, Sept. 9, 1926 (shrub 60–90 cm.; flowers white); dry shale slopes under Oaks at Nyipa in Mayaku, alt. 2400 m., no. 15055, Sept.–Oct. 1926 (shrub 60–90 cm.; flowers pinkish white).

Aster poliothamnus Diels in Fedde, Rep. Spec. Nov. Beih. XII. 503 (Bot. Reis. Hochgeb. Chin. Ost-Tib.) (1922).

EASTERN TIBET. Radja and Yellow River gorges: among conglomerate boulders in valley near Radja lamassery, alt. 3000 m., no. 14201, June 1926 (flowers lavender).

A distinct and handsome species with numerous lavender-colored flower-heads.

Microglossa salicifolia Diels in Bot. Jahrb. XXIX. 612 (1900).

SOUTHWESTERN KANSU. Lower Tebbu country: gravelly rocky banks of Peshwekiang, alt. 2050 m., no. 14555, Aug. 30, 1926 (shrub about 1 m.; flowers white); banks of stream, Peshwekiang gorge, alt. 2050 m., no. 14800, Sept. 5, 1926 (forming large clumps; flowers white).

Tanacetum Rockii Mattfeld, spec. nov.

Frutex parce ramosus; rami vetustiores lignescentes, cortice griseo tenuiter rimoso obtecti, hornotini herbacei, simplices sursum tantum ramulosi, supra basin foliis delapsis nudi, deinde laxe foliati (internodiis 1–3.5 cm. longis), costati, tenuiter appresse pilosi, deorsum glabrescentes, sursum griseo-tomentelli. Folia sursum magnitudine sensim decrescentia petiolata; petioli tomentelli, 2–5 mm. longi, basi utrinque lobulo herbaceo stipuliformi ornati; laminae ambitu fere rotundatae, 1–2 cm. latae, 1–1.7 cm. longae, basi truncatae et deinde breviter in petiolum angustatae, margine vix ad tertiam partem sinuatae, supra virides, dense granuloso-punctatae, subtus dense appresse incano-tomentosae, palminerviae, nervis subtus leviter prominulis e basi 3 rarius 5, venam unicam saepius tantum emittentibus, exeuntibus in lobos, lobi 3, inaequi-

formes, apicali iterum trilobulato, lobulo medio late ovato usque subquadrato, interdum utrinque 1-dentato, ca. 3–6 mm. longo, 5–7 mm. basi lato, lateralibus oblique ovatis, lobis 2 lateralibus grosse sinuato-tri-crenatis, crenis deorsum magnitudine decrescentibus, lobulis omnibus obtusiusculis breviter mucronulatis. Inflorescentiae paniculato-corymbosae, axes inferiores ex axillis foliorum orientes bene foliati, 20–6 cm. longi, superiores axi primario brevius longiusve adnati, bracteis foliaceis integris oblanceolatis sparse obsiti, 5–2 cm. longi, omnes corymbulo parvo glomeruliformi, 1–2.5 cm. diametiente, bracteolis parvis lineari-lanceolatis usque filiformibus obsito terminati, pedunculis propriis tomentellis 0.5–3 mm. longis. Capitula minuta, heterogama; involucri globosi, apice constricti, ca. 2–2.5 mm. diametientes et alti; squamae 3–4-seriatae, glabrae, exteriores ovatae, 1.2–2.2 mm. longae, 0.8–1.2 mm. latae, subobtusae, interiores late ovato-rotundatae, 2–2.5 mm. longae, 1.8–2 mm., latae, latissime scariosae; receptaculum convexum, vix 1 mm. diam., nudum, glabrum; flores omnes fertiles, marginales feminei uniseriati, tubulosi, lobis 5 ovato-lanceolatis 0.5 mm. longis inclusis 2 mm. longi; corolla sparse glandulis megacephalis sessilibus obsita ceterum glabra; flores disci tubulosi hermaphroditi, sparse glandulosi, 2.2 mm. longi, tubus 1 mm. longus, subito paullumque ampliatus in limbum lobis 5 ovatis 0.5 mm. longis inclusis 1.2 mm. longum; styli rami 0.5 mm. longi, apice truncato barbulati; germen epapposum, oblique obovoideum, glabrum, vix striatulum, (coctum) mucilaginosum.

Southwestern Kansu. Lower Tebbu country: banks of Chulungapu near Wantsang, 1980 m., no. 15097, Sept. 1926 (plant 60–90 cm.; flowers yellow).

Aliam speciem generis hacum foliorum forma camparandam frustra quaesivi, nisi habes folia ceterum longe alieni *Chrysanthemi sinensis* aliquo modo pro similia; notabilia etiam achaenia ecostata, minutiuscule striatula, mucilaginosa ita iis Artemisiarum similia.

Tanacetum salicifolium Mattfeld, spec. nov.

Suffrutex e basi parce ramosus, 30–40 cm. altus; rami vetustiores foliis delapsis nudo, lignescentes, cortice griseo, tenuiter rimoso obtecti, foliorum fasciculo rosulante, anno sequente ramum fertilem terminalem evolvente terminati; innovationes e ramis vetustioribus (iam defoliatis) hornotini steriles, breves, 3–10 cm. longi, deorsum laxe sursum dense fasciculatim foliati; rami floriferi simplices e rosula singuli, 12–20–30 cm. alti, inflorescentia terminati, usque ad apicem laxe foliati (internodiis 0.5–2 cm. longis), fuscescentes, tenuiter arachnoideo-tomentelli. Folia herbacea, simplicia,

anguste lineari-lanceolata, (2–) 5–7 cm. longa, 2–5 (–10) mm. lata, basin versus sensim longeque petiolatim angustata vel fere rite alato-petiolata et deinde basi dilatata ramo affixa, apicem versus tardius angustata, obtusiuscula et mucronata usque breviter acuminata, margine integerrimo saepius minute revoluta, supra viridia, primum laxe arachnoidea demum glabrescentia, subtus incano-tomentella, nervo tenui percursa. Inflorescentia corymbosa, semiglobosa, saepe glomerata, 3–4 (6) cm. diametiens et aequealta; pedunculi communes dense tomentosi, 3–6-capitulati, 1–1.5 (–4) cm. longi, pedunculi proprii 1–3 mm. longi; capitula heterogama pluriflora; involucri demiglobosi, 4–6 mm. diametientes; squamae ca. 4-seriatae, dorso herbaceae, laxe arachnoideae, late fusco- vel atrofusco-membranaceo-marginatae, exteriores late ovatae acutae, interiores late obovatae, apice lacerato late rotundatae obtusissimae; receptaculum nudum, glabrum, ca. 1.5 mm. diam., convexum; flores omnes fertiles, marginales feminei uniseriati; corolla anguste cylindrica, sursum attenuata, vix 3 mm. longa, sub lobis 4–5 ca. 0.6–0.8 mm. longis constricta, glandulis sessilibus obsita; flores disci hermaphroditi cylindrico-tubulosi, sursum paullum ampliati, 3.5 mm. longi, glandulis sessilibus obsiti, lobi 5 ca. 0.5 mm. longi; styli rami breves, apice truncato barbati; germen epapposum, angulato-obovoideum, glabrum, eglandulosum, costatum, florum marginalium dorso applanatum.

CENTRAL KANSU: Lien hoa shan: among limestone rocks on summit, alt. 3450 m., no. 12693 (typus) July 1925 (shrub 60–90 cm., flowers yellow).

NORTHERN SZECHUAN: Dongrergo, Gebüschhänge mit Spiraea, Potentilla, Juniperus, 4000–4200 m., *Harry Smith*, no. 3529, Aug. 8, 1922; same locality sonnige Blockhänge bei Huang-lung-ssu, 4000–4150 m., *Harry Smith*, no. 3620, July 22, 1922.

SOUTHWESTERN SZECHUAN (Muli Kingdom): mountains between Wa-Erh-Dje and Muli Gomba, in open meadows, 4350 m., no. 16918, Aug. 8, 1928 (height 60–180 cm., flowers yellow).

Species nova foliis integris anguste lanceolatis inter alias species generis eximia. Specimen no. 16918 foliis amplis ad 10 cm. longis et 1 cm. latis longius acuminatis, inflorescentia paullum altiore, statura elatiore a typo differt.

Tanacetum falcatolobatum H. Krashenikov in Not. Syst. Herb. Petrop. IV. 7 (1923).

CENTRAL KANSU. Yellow River basin: rocky gorge of Hsining beyond Hsiang tang, alt. 2125 m., no. 13246, Aug. 1925 (woody plant, 0.3–0.6 m.; flowers yellow).

EASTERN TIBET. Radja and Yellow River gorges: among rocks, banks of river, alt. 3050 m., no. 14193, June 1926 (shrub 0.6 m.; flowers yellow).

Pertya sinensis Oliver in Hooker's Icon. XXIII. t. 2214 (1892).

SOUTHWESTERN KANSU. Upper Tebbu country: Spruce forests of Drjakana, overlooking Yiwaku valley, alt. 3200 m., no. 13100, Aug. 3, 1925 (shrub 2.5–3 m., with scandent branches; flowers pink); among Picea and Abies trees, forest of Drjakana, alt. 3050 m., no. 14588, Aug. 1926 (shrub 3 m.; flower-heads slender, purplish). Lower Tebbu country: on banks of streams in Wantsang forest, alt. 2225 m., no. 14668, Aug. 31, 1926 (shrub 1.25–1.50 m.); along streams and rocky banks, Mayaku, alt. 2450 m., Sept.–Oct. 1926 (shrub; flower-heads single).

Pertya discolor Rehder in Jour. Arnold Arb. x. 135 (1929).

CENTRAL KANSU: en route to Lin-hoa-shan from Choni via Taochow, among scrub, no. 12667 (type), July 1925 (shrub 1 m., florets dark purplish red).

(*To be continued*)

CYTOLOGICAL STUDIES OF CORNUS

HAIG DERMEN

With plate 53

THERE ARE some forty or more species of *Cornus*, of which some thirty forms are in cultivation at the Arnold Arboretum. This genus has quite a wide distribution all through the northern hemisphere, with one species in the tropical mountains of Africa (Wangerin 1910). According to Berry (1923) over fifty fossil forms have been described, the oldest of these coming from the Upper Cretaceous period; the majority of other forms have been found all through the Tertiary formations.

Out of fifty existing forms described by Wangerin (1910) and Rehder (1927) twenty-four are found in central and eastern Asia, two in western Asia, one in western Asia and Europe, ten in Atlantic North America, six in Pacific North America, three in Central America, one in Alaska and middle western United States, one in Africa and two in the boreal and arctic circumpolar region. All but the last two mentioned are woody while the latter forms are perennial herbs.

Twenty-three species of *Cornus* and one species of *Nyssa* were studied and their chromosome numbers determined. *Cornus canadensis* material was procured from the woods near Pepperell, Mass. This species was studied from aceto-carmin smear preparations of pollen mother cells. The other species were from the Arboretum plants. Five of these were studied both from root-tip section preparations and from aceto-carmin smears. The others were determined from root-tip sections. Representative forms are illustrated in Plate 53. The technique of obtaining root-tips for cytological preparations is described in an earlier publication (Dermen 1931).

A table is given below showing the basis of the taxonomic grouping of the genus *Cornus* based on Rehder's classification (1927), but with slight alterations, and the corresponding chromosome grouping of the species investigated.

TABLE I.

A. Flowers in cymes or panicles without an involucre.
  B. Leaves alternate ..... (10 pairs of chromosomes)
    Cornus alternifolia, C. controversa.
  BB. Leaves opposite ..... (11 pairs of chromosomes)
    Cornus alba, C. alba Rosenthalii, C. stolonifera, C. stolonifera flaviramea, C. stolonifera coloradensis, C. rugosa, C. Amomum, C. obliqua, C. arnoldiana, C. asperifolia, C. glabrata, C. racemosa, C. paucinervis, C. coreana, C. sanguinea, C. Bretschneideri.

AA. Flowers in dense umbels with an involucre.
B. Flowers yellow with a yellowish involucre not exceeding the flowers and deciduous during anthesis.....(9 pairs of chromosomes)
Cornus mas, C. officinalis.
BB. Flowers greenish yellow with large white or pink bracts.
C. Woody plants.....(11 pairs of chromosomes)
Cornus florida, C. kousa chinensis.
CC. Herbaceous plant.....(22 pairs of chromosomes)
Cornus canadensis.

From the above table it is seen that chromosome numbers correspond to the system of taxonomic grouping. This investigation showed four groups of species with basic chromosome numbers 9, 10, 11, 22. In Plate 53 are illustrated meiotic and mitotic figures as representative of cytological groups. Meiotic chromosomes of *C. mas* (fig. 1) are considerably larger than the meiotic chromosomes of *C. florida* (fig. 2) and much larger than the chromosomes of *C. canadensis* (fig. 3). These size differences are also noticeable in the somatic chromosomes (*C. mas*, fig. 4; *C. florida*, fig. 5). Both meiotic and somatic chromosomes of *C. officinalis* correspond in size and structure to the *C. mas* chromosomes. *Cornus kousa chinensis* (fig. 6) was similar to *C. florida* in all respects; both had one pair of chromosomes with minute trabants. There were no trabants observed in any other species. The chromosomes of the *C. alba* group were somewhat smaller than the chromosomes of the *C. mas* and *C. florida* groups. In this, as well as in the *C. florida* group a pair of chromosomes were noticeable that were conspicuously longer than the others, with double constrictions (*C. stolonifera*, fig. 7; *C. stolonifera flaviramea*, fig. 8). Most of the other chromosomes had subterminal constrictions (*C. paucinervis*, fig. 9). *Cornus controversa* (fig. 10) and *C. alternifolia* have 20 chromosomes. In these species there were found four chromosomes that were much longer than the others in the cell. It was difficult to find a cell with chromosomes in a flat position making it possible to illustrate this point; however, with careful observation these differences could be noticed. Winge (1917) has reported for *C. racemosa* (*C. candidissima*) the chromosome count n = 8–9 and for *C. glabrata* n = 11–12. Both these species have 11 pairs of chromosomes.

Attempts were made to study other genera that are classified either within the family Cornaceae or in Nyssaceae to see in what respects they may have affinities to the genus *Cornus*. *Nyssa sylvatica* was the only species available for a study of chromosome number, size, and structure. This species has 44 chromosomes (fig. 11) quite small in size, but showing at least two pairs of chromosomes noticeably longer than the others. Several efforts were

made to study *Helwingia japonica* and *Davidia involucrata* (the only species of these genera available in the Arboretum) but the chromosomes were found too crowded together, thus making an accurate count difficult. The chromosome number for *Davidia* was estimated 40 ± and for *Helwingia* 80 ±. Both had small chromosomes like *Nyssa*. The root-tip cells of *Cornus*, *Nyssa* and *Davidia* were of the same nature; half of them were thick walled showing the presence of a gummy substance. *Helwingia* did not possess these gum cells.

Cornus mas (fig. 4) and *C. officinalis* have 9 pairs of chromosomes. The somatic chromosomes of these forms indicate the presence of 2 pairs with median or submedian constrictions. These 3 pairs are longer than the other chromosomes of the group. When other forms are compared with these, one finds that all the chromosomes are quite short with only one long pair and with a double constriction. From these facts it may be concluded that the two median constricted pairs were segmented, giving rise to the four extra chromosomes of the 11 pair group. The chromosomes of the 10 pair group showed two pairs that were considerably longer than the others. In this case, apparently only one of the nine pairs was segmented to give rise to this additional pair. The 22 pairs of chromosomes of *C. canadensis* undoubtedly are from the duplication of the 11 pairs of some species like *C. florida* or some herbaceous diploid form. To shed some light on the origin of this species with a tetraploid number of chromosomes, the author intends to study *C. suecica*, another herbaceous species, and some other varieties of *C. canadensis*.

From the chromosome counts and structure it is suggested that nine pairs may be taken as the basic number of the genus and that other forms with 10, 11, and 22 pairs are merely alterations of this basic number due to segmentation of some chromosomes and duplication in the case of *C. canadensis*. There is evidence in supporting the hypothesis that fragmentation of chromosomes may give rise to new forms. Stern (1928) gives a case described by Seiler that clearly demonstrates this point. There were found two races of butterflies, *Phragmatobia fuliginosa*, one with 28 and the other with 29 pairs of chromosomes. Seiler finds that the long chromosomes of the 28 pair race are four units long, while in the 29 pair race the long chromosomes are three units long. When these races are crossed he finds that long chromosomes pair with the fragmented chromosomes. Anderson (1931) has made a comparative study of the chromosomes of the genera *Allium* and *Nothoscordum*. The genus *Nothoscordum* is considered closely

related to the genus *Allium*. In *A. stellatum* he finds seven pairs of chromosomes, while the characteristic number for the genus is eight pairs. In *N. bivalve* are found nine pairs. In the nine chromosomes of the microspore, seven were with median or sub-median constrictions and two with terminal constrictions. In the words of the author, "These latter are conspicuously marked by large, deep-staining insertion points. The chromosomes, like those of *Allium*, are large and ribbon-like. The attachment constrictions in *Allium* are usually median or sub-median (or at most sub-terminal). It seems quite possible that *Nothoscordum* may have been derived from an eight-chromosomed parental stock by the division of one of the large median-constricted chromosomes. This is further borne out by the fact that the combined length of the two chromosomes with terminal constrictions is only a very little greater than that of the longest chromosome with a median constriction." Thus it may be assumed that when a long chromosome is fragmented from the point of so-called "spindle fiber attachment point," then the derived chromosomes build up anew their own spindle fiber attachment constrictions.

It may be safe to assume that a species with a small number of chromosomes is the most primitive of its genus. Taking the cytological findings based on number, size and structure of chromosomes, it may be said that a type like *C. mas* is the most primitive of the genus and others are derivatives of this, both in respect to cytological characteristics and morphology of inflorescence.

Unfortunately, due chiefly to difficulties of cultivation, the Arboretum does not have some of the species like *C. Volkensii*, *C. cilicia*, *C. Nuttallii*, etc. that could have helped to make this study more complete. These species mentioned are of special interest because of their geographical distribution and because, in some cases, of their close resemblance to other forms, like *C. Nuttallii* to *C. florida*, the former growing in Pacific United States and the latter in Atlantic United States.

The present distribution of these species suggests that *Cornus* was an ancient genus dating back into the Lower Cretaceous period, before, according to geographical formations discussed by Fernald (1931), the Arctic Ocean had connection with the Gulf of Mexico, when there were supposed to be land connections between North America and Europe, Africa was connected with Europe and Transcaucasia was the land bridge between Europe and Asia. The facts that *C. mas* has the least number of chromosomes and other points indicated above, and that there are many varieties of *C. mas* growing all through that region, and that Transcaucasia

is in the middle point of the early geographical formation of the earth, indicate that forms with higher number of chromosomes may have been derived from *C. mas* and these forms spread to the left through Europe and America and to the right through Asia and down to the present African tropical mountains. Two species, *C. alternifolia* and *C. controversa* (alternate leafed), with two additional chromosomes are very similar. The former has moved to the west occupying Atlantic North America and the latter moved to the present tropical regions of the East Indies, China, Korea and Japan. Other forms with four additional chromosomes must have originated from *C. mas*, changing morphologically in some respects but retaining the opposite position of leaves. Other species with 11 pairs of chromosomes are most likely derivative forms of a species like *C. florida* or may very well be direct descendants of *C. mas*.

It was stated above that *Nyssa sylvatica* had 44 chromosomes and that there were observed two pairs of chromosomes considerably longer than others. If this observation is correct, then this genus may be considered a derivative form of a Cornus species with 11 pairs of chromosomes.

In connection with the chromosome study of *Cornus*, pollen grains of 25 species were measured and the percentage of pollen grain abnormality was determined.

TABLE II.

Name of Species	Per Cent of Pollen Grain Abnormality	Measurement in μ
C. alba Rosenthalii	15	215
C. alba Kesselringii	50	260
C. stolonifera	2	215
C. stolonifera flaviramea	2	215
C. stolonifera coloradensis	5	260
C. rugosa	30	205
*C. Slavinii**	15	215
C. Amomum	30	280
*C. dubia**	65	245
C. obliqua	4	250
*C. arnoldiana**	80	190
C. asperifolia	25	200
*C. Dunbarii**	75	215
C. glabrata	2	215
C. racemosa	50	180
C. coreana	10	215
C. Bretschneideri	2	205
C. florida	10	170
C. florida rubra	95	160
C. kousa	70	135
C. kousa chinensis	3	125
C. mas	3	110
C. mas flava	3	110
C. officinalis	2	110
C. canadensis	10	110

In the above table are given the species that were studied and recorded. Species with asterisks are hybrids. These are given in Rehder's Manual of Cultivated Trees and Shrubs, 1927. The measurements in microns are 180–280 for *C. alba* group, 125–170 for *C. florida* group, 110 for *C. mas* group, and 110 for *C. canadensis*. This record shows most strikingly that chromosome number and size do not control the size of pollen grains, while on the other hand, each group has its characteristic measurement. It was also found that *C. mas*, *C. florida*, *C. kousa*, *C. officinalis*, and their varieties develop their pollen grains in the fall, while others develop theirs in the spring. In this respect there was found an affinity between the *C. mas* and *C florida* groups. *Cornus canadensis*, while related to *C. florida*, develops its pollen grains in the spring. This difference may be due to its being an herbaceous form.

From all the above facts it is suggested that *C. mas* or a similar species is the most primitive type; that the *C. alba* group may be considered as a derivative group from the *C. florida* type or directly from the *C. mas* type; and that the *C. florida* and *C. alternifolia* groups are parallel derivatives from the *C. mas* type. *Cornus canadensis* should be considered a derivative from the *C. florida* type. At present nothing can be said concerning *Davidia*, only that the root-tip cells were similar to *Cornus* and *Nyssa*, and that the chromosome number is estimated to be 40 ±.

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DESCRIPTION OF PLATE 53

Fig. 1. *C. mas*. Second metaphase plate showing at one pole 9 chromosomes.
Fig. 2. *C. florida*. First metaphase plate with n = 11 chromosomes.
Fig. 3. *C. canadensis*. First metaphase plate with n = 22 chromosomes.
Fig. 4. *C. mas*. Metaphase plate from root-tip section with 2n = 18 chromosomes.
Fig. 5. *C. florida*. Metaphase plate from root-tip section with 2n = 22 chromosomes.
Fig. 6. *C. kousa chinensis*. Metaphase plate from root-tip section with 2n = 22 chromosomes.
Fig. 7. *C. stolonifera*. Metaphase plate from root-tip section with 2n = 22 chromosomes.
Fig. 8. *C. stolonifera flaviramea*. Metaphase plate from root-tip section with 2n = 22 chromosomes.
Fig. 9. *C. paucinervis*. Metaphase plate from root-tip section with 2n = 22 chromosomes.
Fig. 10. *C. controversa*. Metaphase plate from root-tip section with 2n = 20 chromosomes.
Fig. 11. *Nyssa sylvatica*. Metaphase plate from root-tip section with 2n = 44 chromosomes.

Cytological Studies of Cornus

LEAVES FROM A COLLECTOR'S NOTE BOOK

ERNEST J. PALMER

With one text figure

Gainesville, Fla., April 6, 1931.

THE UPLANDS about Ocala, where we began collecting today, are covered for the most part with a deposit of fine sand overlying the soft porous limestone, which latter deposit is quarried extensively here for road building. These sandy uplands support a mixed growth of Pine (*Pinus echinata* and *P. caribaea*) and of deciduous species, amongst which are *Carya alba*, *Quercus laurifolia*, *Q. cinerea*, *Q. rubra*, *Q. Chapmanii*, *Q. stellata* var. *Margaretta*, *Diospyros virginiana*, *Crataegus constans*, *C. amica*, *C. inopina*, *Rubus cuneifolius*, *Prunus umbellata*, *Rhus quercifolia*, *Ceanothus microphyllus*, *Asimina speciosa*, and *Viburnum rufidulum*. In dryer places this gives place to a more stunted growth, largely of shrubby species, locally known as scrub, in which *Quercus Catesbaei*, *Q. myrtifolia*, and *Q. cinerea* are often common, with *Xolisma ferruginea*, *X. lucida*, *Osmanthus americana* and sometimes *Pinus clausa*. Many interesting herbaceous plants grow here also, of which *Lupinus diffusus* is one of the most common and conspicuous.

Most of the *Crataegus* of the open upland woods, including the three species mentioned above, belongs to the very distinct *Flavae* group, and the trees have a strange appearance with their generally stiff, recurved, branches, slender drooping branchlets, and trunks covered with thick black bark, that is deeply fissured and divided vertically and horizontally, having much the appearance of that of the Flowering Dogwood.

We drove out in the forenoon to the Ocala National Forest, and as we reached the lowlands and flood plains along the Oklawaha River, which we crossed near Silver Springs, it was interesting to note the sudden change in the character of the forest. Cabbage Palmettos growing amongst the Pines, just before we reached the river, looked strangely incongruous.

The soil of the river valley is stiff and black and largely calcareous. The Pines disappear and give place to *Taxodium distichum*, *Quercus nigra*, *Ulmus floridana*, *U. alata*, *Celtis laevigata*, *Crataegus viridis* and *Fraxinus profunda* var. *Ashei*,[1] with *Rhus Toxicodendron*

[1] **Fraxinus profunda var. Ashei, var. nov.**

A typo differt foliolis glabris vel raro secus nervos parce tomentosis, sepalis minoribus 1–1.5 mm. longis.

A slender tree 10–12 m. tall, with ascending branches and trunk up to 3–4 dm. in diam. Bark rough and deeply furrowed. Leaves ovate-lanceolate in outline, 1.5–3.5

and *Sabal glabra* amongst the undergrowth. Some of the dwarf Palmettos here were nearly two meters tall. A few trees of *Quercus Shumardii* were seen growing just above the swampy flood plains.

In the afternoon we stopped just north of the boundary of Alachua County, near the village of Micanopy, to examine the *Crataegus*, of which several species were in bloom. Besides *Crataegus egens* and *C. Brittonii*, another species was abundant, which from the characters of the flowers and leaves apparently belongs to the *Parvifoliae* or *Uniflorae* group, but differs in habit from most of them, as it becomes a small spiny tree 3–4 m. tall. The flowers are single or two or three together and have 20 stamens, yellow anthers and 5 styles, as in *C. uniflora*, and also have the large conspicuously glandular-serrate calyx lobes of that group.

dm. long; leaflets 5–9, usually 7, ovate-lanceolate or lance-elliptic, cuneate or rarely rounded at base, acuminate at apex, usually entire, petiolules of the lateral leaflets 5–15 mm. long, those of the terminal leaflet 2–5 cm. long, glabrous or rarely with tufts of brown tomentum along midrib and principal veins; fruit in ample panicles, 5–18 cm. long; samaras flattened, spatulate-lanceolate or linear-lanceolate, 3.5–6 cm. long, 0.6–1 cm. wide, obtuse, rounded, or retuse at apex, longitudinally striate on wings and less conspicuously so on body of seed on which the wing is decurrent to the middle or below; fruiting calyx narrowly campanulate 4–5 mm. long including the ovate-lanceolate calyx-lobes, which are 1–1.2 or rarely 2 mm. long.

This small tree, which inhabits the wet river swamps of the coastal plain from Maryland to Florida, seems to be intermediate between *Fraxinus caroliniana* and *F. profunda*, with both of which specimens have been confused. Specimens in the herbarium of Arnold Arboretum, from the Apalachicola River, Florida, have the young branches and leaves densely pubescent as in typical *Fraxinus profunda* to which they are correctly referred, but I have seen specimens from River Junction, Florida, in which the mature leaves are glabrous, and other specimens appear to be intermediate, and for this reason I think it better to regard the glabrous or sparsely pubescent form as a variety of *F. profunda* rather than a distinct species.

My attention was first called to this tree by Mr. W. W. Ashe, for whom the variety is named, and on whose notes and collections I have drawn to supplement my own made this season in the region where it grows.

Maryland: Dorchester Co., *J. A. Cope*, Sept., 1923; eastern shore, *G. Beasley*, June 20, 1922; Potomac River swamps, s. of Washington, *W. W. Ashe*, Sept. 18, 1927. Virginia: Alexander Island, Alexandria Co., *W. W. Ashe*, nos. 1, 6, and 7, Sept. 18, 1924; near Alexandria, *Jos. H. Painter*, no. 912, Aug. 9, 1904. North Carolina: On Brogaw River, near Northeast Cape Fear River, Pender Co., *W. W. Ashe*, Oct. 30, 1928; Pender Co., *E. J. Palmer*, no. 38256, March 28, 1931; Raleigh, *W. W. Ashe*, no. 1008, Oct. 10, 1895; Hillsboro Road, Raleigh, *J. G. Ashe*, April 20, 1924. Georgia: Athens, *J. H. Miller*, no. 103, Sept. 1923. Florida: Santa Fe River, Alachua Co., growing in water, *W. W. Ashe*, June 4, 1892; near Hildreath, *W. W. Ashe* (**type**) May 15, 1929; between Ft. White and Hildreath, *W. W. Ashe*, June 4, 1929; Oklawaha River swamps, Marion County, *W. W. Ashe*, April 26, 1929; between Ocala and Sulphur Springs, Marion County, *W. W. Ashe*, April 14, 1928; River Junction, without date, *W. W. Ashe;* Kissimmee, Osceola County, *E. J. Palmer*, no. 38356, April 2, 1931; low swampy woods along Oklawaha River, near Silver Springs, Marion County; *E. J. Palmer*, no. 38404, April 6, 1931; low wet woods, near St. Marks, Wakulla County, *E. J. Palmer*, no. 38507, April 10, 1931. Indiana: in a pond about 2 miles n. of Brownstown, *C. C. Deam*, no. 11987, Aug. 8, 1912; very sandy soil, low woods, n. shore of Bass Lake, Starke Co., *C. C. Deam*, no. 17916, Aug. 19, 1915; very low place in White River bottoms 3.7 miles e. of Mendora, Jackson Co., *C. C. Deam*, no. 19038, Sept. 13, 1915; on an old beach line, n. side of Bass Lake, Starke Co., *C. C. Deam*, no. 21063, Aug. 22, 1916; low place along roadside, 4 miles s. of Columbus, Bartholemew Co., *C. C. Deam*, no. 30251, Sept. 27, 1919. Missouri: Campbell, *B. F. Bush*, nos. 436, Aug. 15, 1895, 6596, April 19, 1912. Louisiana: Harvey's Canal, New Orleans, *R. S. Cocks*, no. 30, April, 1902.

Tallahassee, Fla., April 7th.

Our first stop this morning was a few miles south of Gainesville, where *Crataegus* was abundant and several species were in bloom, growing in deep fine sands. The species collected in the thickets and along the border of open woods here were *C. integra*, *C. impar*, *C. fortis*, *C. adusta* and *C. gregalis* ?, as well as the *Parvifoliae* species, like the one we saw at Micanopy yesterday. Here also it becomes a small pyramidal tree, 4–5 m. tall, with intricate spiny branches.

Near Bronson *Xolisma lucida* was growing in a small swamp filled with the Pond Cypress, and some of the specimens were 4–5 m. tall.

In sandy upland woods near Chiefland, Levy County, *Crataegus amica* and *C. egens* were in bloom, and in burned over ground there were large patches of *Castanea alnifolia*, both sterile and fruiting, none of them more than 3–5 dm. tall.

About noon we crossed the Suwannee River at Old Town and stopped on the west side for lunch and to work the collections. *Betula nigra* is growing on the river banks here. The leaves appear to be small and unusually thick for the species, but it can scarcely be more than a geographical form. *Viburnum obovatum* was also collected here in young fruit, but with a few clusters of flowers still remaining. It is a small tree here, the largest specimens being 6–7 m. tall. *Quercus lyrata*, *Q. stellata* var. *Margaretta*, *Acer rubrum* var. *Drummondii* and the curious little Cycad, *Zamia floridana*, were also collected, and I photographed a fine clump of *Lupinus villosus* in sandy soil along the river bank.

April 10th.

This morning, accompanied by Dr. Harper and a local ornithologist we set out to visit the old town of St. Marks, near the mouth of the River of the same name, where a good deal of botanical collecting has previously been done. About ten miles south of Tallahassee we stopped in a bit of flat pine woods to examine a colony of broad leaved trees and shrubs occupying a little depression or hammock. A large tree of *Cornus florida* was in bloom here. The trunk below the first fork, which was only about a meter and a half above the ground, was over 3 dm. in diameter, and the height of the tree, though not measured, must have been 9 or 10 meters. A little further on we found *Crataegus viridis* quite abundant in low wet woods and in the sandy soil on higher ground we collected *Bumelia reclinata*, which was here a shrub about a meter high.

Near Newport, on the St. Marks River, the Florida Elm (*Ulmus floridana* Small) is abundant in the low wet woods. This tree, although closely related to *Ulmus americana*, has quite a distinct ap-

pearance on account of the conspicuously buttressed bases of the trunks and its small leaves. Some of the trees had a curious appearance from the markings caused by woodpeckers, which for some reason that I am unable to explain encircled the trunks in bands at rather regular intervals, giving them a sort of jointed appearance. We had lunch here at the picnic grounds and afterwards explored the woods, collecting *Juniperus lucayana* and *Viburnum scabrellum*, and in shallow muddy ponds the little Quillwort, *Isoetes flaccida*. Some of the native trees, as well as the Pecans cultivated about the town, were well loaded with great clusters of Mistletoe (*Phoradendron flavescens*), and I secured a photograph of one of these.

A *Crataegus* of the *Crus-galli* group was abundant in the open parts of the swampy woods, and I examined many of them here as well as others later in the day about Wakulla and St. Marks. The type of Sargent's *Crataegus limnophila*[1] came from St. Marks, and it is described as having flowers on slightly villous corymbs and 15–20 anthers of dark rose-color. Some of the trees observed here quite agree with the description in these and other respects, but others growing with them, quite identical in habit, foliage, bark, fruit and other characters, have the flowering corymbs in some cases quite glabrous, and there appeared to be a complete gradation from these to others in which the branchlets and petioles as well as the corymbs and hypanthiums are copiously villous. The flowers of all the trees examined here have 15–20, mostly 20 stamens and red anthers, but specimens collected a few days later at Chattahoochee have only 10 stamens, and slightly villous corymbs. By comparing these specimens with the glabrous species described from Florida by Beadle as *Crataegus pyracanthoides*[2] said to have 7–10 stamens and red anthers, it seems evident that they are both forms of one species, as there is a very clear identity in the foliage, flowers and fruit and all other characters except pubescence and variation in the number of stamens. It seems clear, therefore that these should be regarded as only varieties of one species, and the glabrous form, usually with 10 stamens, but sometimes as many as 20, should be known as *Crataegus pyracanthoides* Beadle, while the form with corymbs and sometimes foliage and branchlets more or less villous becomes *C. pyracanthoides* var. **limnophila** (Sarg.), comb. nov.

This also shows how impracticable it is to maintain the group distinction made by Beadle between *Crus-galli* and *Berberifoliae*, based merely on pubescence.

[1] Jour. Arnold Arb. III. 3 (1922).
[2] Biltmore Bot. Studies, I. 136 (1902).

About the old town of St. Marks, lower down the river, both the pubescent and the typical varieties of this *Crus-galli* species are even more abundant, and in addition I collected here *Crataegus integra*, *C. amica*, and *C. assimilis*. The Honey Locust (*Gleditsia triacanthos*) is growing in the swampy woods here and some of the trees examined have unusual bark for this genus, that on the old trunks being dark, thick, and very rough, with fissures and ridges divided into short blocks, much as in *Cornus florida* or *Diospyros virginiana*. I photographed the trunk of one tree with this sort of bark, and I think that no one familiar with the typical appearance of this tree farther north would recognize it. However, I can find no differences in the fruit, flowers or foliage to justify regarding it as distinct.

April 11th.

The Apalachicola River, which crosses the western part of Florida is formed by the junction of the Chattahoochee and Flint Rivers, just north of the state line, in Georgia. In this part of Florida it has cut its channel deeply through beds of soft Tertiary limestone, developing in places distinct bluffs and ecological and soil conditions quite different from those of other parts of the state, which accounts for the very interesting and distinct flora. We drove out today with Dr. R. M. Harper and a party of geologists from the State Geological Survey, our objective being Allen Bluff in Liberty County. This is one of the highest bluffs of the coastal plain and it is perhaps the highest in Florida. The precipitous part of the cliff which extends for perhaps half a mile along the river, is formed of horizontal strata of limestone and marl. In places it is quite perpendicular but on the slopes there is an abundant growth of trees and shrubs. The soil on the highest levels above the bluff is of deep sand, but ravines cutting through this have penetrated the calcareous beds, and these support a rich growth of both woody and herbaceous plants. Several small trees of the Tumion (*Torreya taxifolia*) were seen here, and amongst other woody plants were *Hamamelis macrophylla*, *Styrax grandifolia*, *Asimina parviflora*, *Stuartia malacodendron*, *Hydrangea quercifolia*, *Quercus austrina*, *Illicium floridanum* and *Celtis pumila* var. *georgiana*. The Christmas fern was also abundant here as well as other ferns. Some large trees of *Populus balsamifera* var. *virginiana* were growing along the lower part of the bluff. In the sandy open woods above, we collected *Ptelea trifoliata* var. *mollis*, *Clinopodium carolinianum* and *Trichostema suffruticosum*, besides several sorts of *Crataegus*, amongst which were *C. integra*, *C. condigna* and *C. armentalis*, besides a small tree of the *Parvifoliae* group, resembling that found near Gainesville, and probably identical with it.

On the return trip our car separated from the rest of the party and took a more northerly route, where following a weatherbeaten and misleading sign, we came out into a piece of deeply rutted sandy country road at places almost impassable and where some of the dilapidated wooden bridges across the streams looked quite dangerous. Before venturing across two or three of the worst of these we stopped to reinforce them by laying loose planks lengthwise for running boards. In the deep sands by the roadside after getting over the worst of this we stopped to collect a little shrub that was in full bloom and very showy with its profusion of violet or purplish flowers. This proved to be *Conradina canescens*, of the Mint family, or a related form somewhat intermediate between that species and *C. puberula*.

April 12th.

This morning we drove out several miles north of Tallahassee, on the invitation of Mr. Goode, manager of the Horseshoe Plantation, to look at a Crataegus tree there. The tree standing near the manager's house is a large symmetrical specimen, about 12 meters tall at a rough estimate. The low conical crown is formed of numerous slender wide-spreading branches, and slightly zig-zag branchlets, unarmed or with a very few slender spines. Most of the flowers were gone, but I secured a few belated ones in which the anthers were still unopened. There was an abundance of last season's fruit under the tree. From a study of this material and other specimens in the herbarium of the Arnold Arboretum it appears to belong to the *Ignavae* group of Beadle, which is closely related to if not a part of the large *Flavae* group. And it seems to be quite distinct from any described species.

A description of this species is given below under the name *Crataegus leonensis*,[1] sp. nov. As contrasted with *Crataegus ignara*,

[1] **Crataegus leonensis**, sp. nov.

Arbor ad 10–12 m. alta; truncus interdum 3–4 dm. diam., cortice profunde rimoso fusco-cinereo vel fere nigro; ramuli graciles, flexuosi, sparse spinis 3–5 cm. longis subvalidis armati. Folia ovata, rhombica vel obovata, 2–4.5 cm. longa, 2–4 cm. lata, glabra, papyracea sed firma, breviter lobata, grosse dentata, apice acuta, basi acuta vel in petiolum 1–2.5 cm. longum glandulosum attenuata. Folia ramulorum novellorum ovata vel sub-rotunda ad 6 cm. longa lataque, basi obtusa, rotunda vel fere truncata. Inflorescentiae compactae, 3–7-florae; flores 1.6–2 cm. diam.; stamina 20; antherae roseae; styli 3–5, plerumque 4; pedicelli breves, 8–14 mm. longi, sparse villosi; calyx sparse pubescens; sepala lanceolata vel lineari-lanceolata, 4–5 mm. longa, 1–1.5 mm. lata, manifesto glanduloso-serrata, extus glabra, intus glabra vel parce pubescentia. Fructus subglobosus, 9–12 mm. diam., rubro-aurantiacus vel rubro-brunneus, lenticellis maculatus; calyx prominens, cavo profundo, columno stylari 1–2 mm. alto; pyrenae 3–5, crassae, 7–8 mm. longae, 4–5 mm. latae, extremis obtusis, dorso sulcato.

A tree 10–12 meters tall, with depressed round top and wide-spreading intricate branches. Trunk up to 3–3.5 dm. diameter, clothed with thick, ridgy, dark gray or nearly black bark. Branchlets slender, zig-zag, sparingly armed with stoutish spines, 3–5 cm. long. Leaves glabrous except for a few short villous hairs along midrib and

it is a larger tree, much less spiny, with larger, thinner leaves which are more coarsely serrate on the margins and often broader

FIG. 1.—CRATAEGUS LEONENSIS Palmer

at the base. The fruit is also firmer. The leaves are thinner and larger than in most species of the *Flavae* group, and are quite

veins on upper surface when young, soon entirely glabrous, thin but firm, ovate, rhombic or obovate in outline, 2–2.5 cm. long, 2–4 cm. wide, coarsely dentate and with 2–3 pairs of obscure lobes above the middle, with stout midrib and 3–5 pairs of primary veins, slightly impressed on upper surface, acute at apex, cuneate or attenuate at base and more or less decurrent on the slender, glandular petioles, which are 1–3 cm. in length; on vigorous shoots, broadly ovate to suborbicular in outline, up to 6 cm. diam., obtuse, rounded or rarely truncate at base. Flowers 1.6–2 cm. in diam., in compact 3–7-flowered corymbs, on slightly villous pedicels 8–14 mm. long; stamens about 20; anthers rose or pink; styles 3–5; calyx and ovary slightly villous; calyx-lobes lanceolate or linear-lanceolate, conspicuously glandular-serrate, glabrous without, glabrous or sparsely pubescent within; bracts numerous, linear or linear-spatulate, very glandular, soon deciduous. Fruit subglobose 9–12 mm. diam., single or in few-fruited, erect or spreading clusters, orange-red or russet when fully ripe, or often green mottled with irregular lenticels of russet color; flesh thin, firm, becoming mellow; fruiting calyx rather prominent with wide deep cavity and column 1–2 mm. high, with persistent or tardily deciduous sepals. Nutlets 3–4 or rarely 5, thick and rounded at the ends, plane on the ventral surface and with prominent rounded ridges and two or three shallow grooves on dorsal surface.

Middle and western Florida, growing in sandy open upland woods.

FLORIDA: Horseshoe Plantation, near Tallahassee, *C. S. Sargent*, March 28, 30, 1914; *T. G. Harbison*, no. 2, Sept. 16, 1919, nos. 5645, 5646, April 6, 1920, no. 5645a, Oct. 6, 1920, nos. 6071, 6072 (**type**), April 3, 1923, nos. 6181, 6182, Sept. 27, 1923; *E. J. Palmer*, no. 38557, April 12, 1931.

similar to those of some of the *Rotundifoliae* species. The rough dark bark and conspicuously glandular petioles, as well as its geographical range, indicate, however, that it properly belongs with the southern *Flavae* group.

Mr. Goode later drove us about the plantation, and I saw several other specimens of this proposed species growing in the sandy open upland woods. Other species of *Crataegus* also found here were *C. adunca*, *C. assimilis* and *C. consanguinea*.

In the afternoon Mr. McDougall and I drove out to Wakulla Springs, where I was surprised to find the Washington Thorn (*Crataegus Phaenopyrum*) growing in the low woods. This species has not previously been known as far south as Florida, so far as I know. In the sandy woods, on higher ground in this vicinity we also collected *Crataegus abstrusa*, *C. clara* and *C. consanguinea*, and two or three other as yet unidentified species.

De Funiak Springs, Fla., April 13th.

Leaving Tallahassee this morning, after taking leave of our friends at the State Geological Survey, where we have been making our headquarters, and accompanied by Dr. R. M. Harper, who plans to accompany us as far as Birmingham, Alabama, we turned west and made our first stop at Chattahoochee, just south of the Georgia boundary.

The geological formation here is a rather pure Tertiary limestone, which forms bluffs and steep hillsides along the river and deep wooded ravines leading down from the uplands. The rich limestone soil and humus accumulated along the slopes and in the valleys supports a rich and varied flora, in places quite suggestive of northern woods, but with a mingling of southern plants.

The beautiful and rare Tumion (*Torreya taxifolia*) attains its best development here. This remarkable tree, a relic of the wide distribution it had in an earlier geological period, is represented in America by this species, confined to a narrow belt in Florida and Georgia, and another (*Torreya californica*) on the Pacific coast. In the Old World there are four species in eastern Asia. The trees here were growing on steep hillsides and in the deep ravines. The largest specimen seen was perhaps 10 metres tall, with numerous spreading and ascending branches dividing about a meter above the ground. The trunk below the first branches had a diameter of 3 or 4 decimeters.

Along the river bluffs and ravines were also growing such familiar northern species as *Quercus alba*, *Ulmus fulva*, *Celtis laevigata*, and *Nyssa sylvatica*, and the low shrubby *Viburnum affine* var. *hy-*

pomolacum. The Columbine (*Aquilegia canadensis*) grows on cliffs and rocky ledges, and *Phlox pilosa* is abundant in the open woods. The most interesting discovery was the northern Prickly Ash (*Zanthoxylum americanum*), which I do not think has been reported from Florida before. *Acer leucoderme* is also abundant on the bluffs and *Crataegus spathulata* and *C. pyracanthoides* var. *limnophila* were found in the low woods along the river.

Elba, Ala., April 14th.

We left the camp at De Funiak Springs early this morning and drove out to the south and east, making our first stop at a crossing of Eucheeanna Creek. The soil here is a reddish loam and appears to be rather fertile. On a bank overhanging the creek we found the beautiful orange-flowered *Rhododendron austrinum* in bloom, and also an abundance of Mountain Laurel (*Kalmia latifolia*). This is the second locality in Florida in which I have seen both of these plants growing together, the other being along the Ocklocknee River in Gadsden County. *Cornus florida* was in bloom in the low woods, the flowers being the largest that I have ever seen, some of them having a breadth across the bracts of more than 12 cm. (4 inches).

A little farther south we got into a poor looking wooded country with hills and ridges dissected by deep ravines. We stopped to explore one of these where a spring flowed out producing a rank growth of ferns and flowering plants, with a great variety of trees and shrubs on the banks and along the little stream. Amongst the ferns were the Christmas Fern (*Polystichum acrostichoides*), Beech Fern (*Thelypteris hexagonoptera*) and Cinnamon Fern (*Osmunda cinnamomea*). The Beech (*Fagus grandifolia* var. *caroliniana*), *Magnolia pyramidata*, *Tilia floridana*, and *Amelanchier canadensis*, were growing on the ridges and banks, and farther down I collected *Viburnum densiflorum*, *Symplocos tinctoria*, *Stuartia malacodendron*, *Styrax grandifolia* and *Cornus alternifolia*.

After returning to camp and loading up our paraphernalia, we proceeded west to Crestview, where we turned south and were soon in the Florida National Forest. *Crataegus lacrimata* is abundant in the sandy open woods about De Funiak Springs and between there and Crestview. It has a very distinct and striking appearance, from the stiff recurved branches and slender pendulous branchlets with very small, spatulate, glabrous leaves, and abundant flowers in small clusters closely set along the branches. The bark is dark and thick, with the ridges curiously cross-fissured, dividing them into short blocks, as is common in this group. Some

of the trees attain a size of 8–9 meters, with trunk diameter of 2 dm. or more.

We were in search of a rare Oak described from this locality a few years ago by Mr. Ashe, as *Quercus caput-rivuli*, and later referred by him to *Quercus arkansana* var. *caput-rivuli*. We stopped for lunch at an abandoned ranger station in a clearing of the Pine woods. The pretty little *Phlox Hentzii* and *Lithospermum Gmelini* were growing in the sands here.

After finishing lunch and working the collections I set out to explore some ravines just back of the house. The fine sand here is underlaid by harder loam and clay, eroding rapidly into these deep ravines with steep or precipitous sides, that work their way back into the uplands. In one of these I soon came upon several specimens of the Oak I was looking for, some of them having acorns. The trees growing here, as well as some seen later in the day, some miles to the north, have straight ascending branches, forming slender pyramidal crowns, and with smooth pale bark. This gives them a rather different appearance from *Quercus arkansana* as it grows in Arkansas and Alabama, and although there is little in the foliage or fruit to distinguish them, it is perhaps best to regard the Florida trees as a variety.

Along these ravines I also collected *Illicium floridanum*, *Clinopodium coccineum* and *Prunus alabamensis*. The last has not, so far as I know, been found in Florida before, and has only been known from limited areas in Alabama and Georgia.

Between Niceville and Laurel Hill, not far from the Alabama line, I again saw *Quercus arkansana* var. *caput-rivuli*, growing in similar situations to the other station and of quite similar habit. *Crataegus lacrimata* was also abundant here, and the little legume *Lupinus Westianus*, was growing in the sandy woods. Along a little creek north of Laurel Hill and just before we crossed the state line, *Clifftonia monophylla* was abundant and in full bloom. Here also I collected *Ilex decidua* and a curious form of *Liriodendron Tulipifera*, the small leaves of which have short, rounded lobes.

Troy, Ala., April 15th.

Our first stop this morning was along a creek near Elba, where we stayed last night, and on the banks of the stream we found the orange-flowered Azalea (*Rhododendron austrinum*) in bloom. This seems to be a northward extension of the known range for this species, which has only been known previously from a few localities in Florida, I believe. The Mountain Laurel and shrubby Pawpaw (*Asimina parviflora*) were also growing here. Three miles north of

New Brockton we collected *Crataegus senta*, growing in open sandy woods. This was a good-sized tree, perhaps 7 meters tall, with the thick rough bark and recurved branches, characteristic of the *Flavae* group. *Crataegus calva*, growing near, has a somewhat similar habit, but was here a smaller tree, and it has larger, more showy flowers.

After passing through Enterprise, and near the west edge of Dale County, we stopped to collect in sandy open woods, and here were found *Crataegus lacrimata*, *C. lenis*, *C. attrita* and *C. gilva*. *Quercus Catesbaei* and *Q. stellata* var. *Margaretta* were also abundant here, and a low *Opuntia* was growing in the sand and nearby, along a little creek we found *Cornus alternifolia* and *Rhododendron canescens*. Near Ozark we added *Crataegus incilis*, and *C. opima* as well as *Bumelia lanuginosa* to our collection, and near Brundidge *Crataegus segnis* and *C. uniflora*.

About noon we reached the "pocosin," a locality that I had for many years been anxious to visit. After turning off the highway we found ourselves on a poor country road, and began plowing our way through the deeply rutted soft sand, which threatened to stall our heavily loaded car. After some maneuvering and a good deal of pushing we managed to get on and stopped for lunch at a primitive little school house on the edge of the woods.

The pocosin embraces an area of perhaps a hundred acres in the sandy uplands, and is traversed by several ravines and small streams which have their sources here. Although the surface deposit of fine nearly pure sand looks quite similar to that of the surrounding areas, which originally were occupied largely by Pine forest, it is well distinguished and its boundaries clearly defined by its rich and peculiar flora of small deciduous trees and shrubs, many of which are only found here in this part of the state. The cause of this marked difference in flora has not been explained, but the hypothesis suggests itself that it may be due to a difference in subsoil, causing the water content of the porous sand to be retained longer than in the surrounding areas, and giving rise to seepage spring along the ravines. Dr. Harper, who was with us and acting as guide, published a short, interesting account of the locality and a partial list of the plants in 1914.[1]

In the very hasty reconnaissance we had time to make it was not possible to get a complete list even of the trees and shrubs, but the following species were collected:

Carya pallida
Quercus alba var. latiloba
Quercus stellata var. araneosa
Quercus laurifolia

[1] Bull. Torrey Bot. Club, XLI. 209–220 (1914).

Quercus velutina	Crataegus bisulcata
Quercus Catesbaei	Crataegus macilenta
Quercus marilandica	Rhus canadensis
Quercus cinerea	Aesculus discolor
Quercus rubra	Prunus umbellata
Quercus arkansana	Acer floridanum
Rhododendron canescens	Tilia floridana
Crataegus Sargentii	Osmanthus americana
Crataegus contrita	Viburnum rufidulum

Quercus arkansana, which was collected here by Dr. Mohr many years ago, but which was not recognized as a distinct species until found by Bush on Red River, in southwestern Arkansas, and described by Sargent in 1911[1] was one of the particular objects of our quest. It is not at all rare here, although not so abundant as in the Arkansas station. I was impressed with the absolute and unmistakable identity of the species in these two widely separated localities as well as the close similarity of soil and ecological conditions under which they grow. There can be no reasonable doubt as to the distinctness of this species, which is one of rarest and most interesting of the American Oaks.

Selma, Ala., April 16th.

We passed through a section of hilly country in Wilcox County, this forenoon, where *Magnolia macrophylla* is quite abundant in open woods along the streams. In Marengo County we crossed a section where a Cretaceous limestone comes to the surface, and the influence of the calcareous soil was plainly seen in the change of flora. Pines were absent here and *Juniperus virginiana* was the only Conifer on the uplands. *Quercus Muhlenbergii* and *Q. Durandii* are characteristic trees in the glades and on the hills. *Crataegus Ashei* was in bloom in the glades. As it grows here it is a very spiny shrub about 3–4 meters tall, with large, handsome flowers. Along the bluffs of Pine Barren Creek, a little farther on Dr. Harper showed us *Dirca palustris* growing along a north-facing bluff.

Near Berlin, Dallas County, we crossed another limestone area and again found *Crataegus Ashei* as well as *C. concinna* and *Rhamnus lanceolata* in the glades and thickets. *Crataegus insidiosa* and *C. frugiferens* as well as an unknown species of the *Pruinosae* group were growing along small streams.

Birmingham, Ala., April 18th.

Dr. H. A. Wheeler, Curator of the Birmingham Museum, who has been our host here, guided us out today to the interesting

[1] Trees & Shrubs, II. 121 (1911).—See also Palmer, E. J. in Jour. Arnold Arb. VI. 195–200 (1925).

locality on Shades Mountain, several miles from Birmingham. I had visited this place with him previously, but was glad of an opportunity to explore it more fully.

There is a scenic road which we followed up the mountain along a line of sandstone cliffs. *Pinus virginiana*, *Quercus marilandica*, *Castanea dentata*, *Celtis pumila* var. *georgiana*, *Amelanchier canadensis* and *Crataegus regalis* were amongst the trees noted here. There are also many interesting herbaceous plants which we did not have time to collect. *Silene Wherryi* and *Senecio plattensis* were conspicuous in the rocky woods. Several ferns are found along the cliffs, one of the most interesting of which is *Asplenium pinnatifidum*, growing in shaded clefts, although it did not appear to be abundant. Besides the Pennsylvanian sandstone, which is found at the lower levels, igneous rocks occur in many places.

At one point where we stopped and spent some time in exploring and collecting, a little stream, Lost Creek, flows across an outcrop of granite and other igneous rocks, which form glades or barrens several acres in extent, and have a distinct and most interesting flora. Over the more exposed parts the vegetation is sparse and consists of mosses, lichens and herbaceous plants, with shrubs and stunted trees that have established themselves in clefts and broken places as well as more abundantly along the rocky margins of the stream.

The rare and pretty little *Dimorpha cymosa* grows in large patches on thin soil of shallow depressions in the granite. *Cheilanthes lanosa*, *Arenaria brevifolia* and *Coreopsis crassifolia* also grow abundantly in the open places. Amongst the woody plants found in the barrens and along the creek are *Quercus Boyntoni*, *Q. georgiana*, *Celtis pumila* var. *georgiana*, *Xanthorrhiza apiifolia*, *Philadelphus hirsutus*, *Amelanchier canadensis*, *Aronia arbutifolia*, *Prunus alabamensis*, *Malus bracteata*, *Crataegus ignava*, *C. venusta*, *Ptelea trifoliata* var. *pubescens*, *Acer rubrum* var. *tridens*, *Oxydendron arboreum*, *Vaccinium sericeum*,[1] *V. vacillans*, *V. tenellum*, *Rhododendron arborescens*, *R. canescens* and *R. alabamensis*.

Quercus georgiana, which is locally abundant, has not before been known from Alabama, and only from the type locality at Stone Mountain, Georgia, and vicinity. It is usually a stout straggling shrub 2–4 meters tall as it grows here, but in better soil in the edge of open woods it sometimes becomes a small tree up to 6–7 meters tall, and with a trunk covered with dark, ridgy,

[1] **Vaccinium sericeum** (Mohr), comb. nov.
Vaccinium melanocarpum [var.] *sericeum* Mohr in Contrib. U. S. Nat. Herb. VI. 658 (Pl. Life Ala.) (1901).
Polycodium sericeum C. B. Robinson in Torr. Bull. XXIV. 570 (1912).

bark. Boynton's Oak (*Quercus Boyntoni* Beadle, or *Q. stellata* var. *Boyntoni* Sargent) is also fairly abundant in the barrens and it is also a shrub 1–3 meters tall. *Vaccinium sericeum* is conspicuous when in bloom on account of its very large flowers, perhaps the largest of any species of the genus. *Prunus alabamensis* is a shrub up to 2–3 meters tall, and it seems to be confined to the rocky glades and creek banks here. *Kalmia* is abundant along the rocky ledges and margins of the creek, and *Rhododendron arborescens*, not yet in bloom, and *Xanthorrhiza apiifolia* were found lower down the creek, where *Cheilanthes tomentosa*, *Thelypteris asplenifolia* and *Tradescantia hirsuticaulis* were also collected. *Rhododendron canescens* and *R. alabamense* were growing abundantly on banks a little above the creek and glades. The latter is rather a rare species and is distinguished by its glabrous winter buds. Over most of the mountain and surrounding region the forest is of larger growth and of mixed stands of Pine (*Pinus echinata*, *P. taeda*, *P. palustris* and *P. virginiana*) and deciduous species, in which Oaks, Hickories, Maple and Ash predominate.

Tupelo, Miss., April 21st.

We came into the little county seat town of Hamilton in a steady rain yesterday evening, and chanced to stop for lodging at a house nearly opposite the district Agricultural High School. After having had supper at the restaurant I talked to our host, a Mr. Love, and explained to him the object of our trip. He proved to be an interesting man, a native of Cape Cod, who had wandered over a good part of the world, and was fond of nature and out-of-doors life. He was much interested in our work and offered to guide us the following morning to some places that he knew, where he thought we would find good collecting.

Accordingly we set out early and after a short drive turned off the highway, near the site of the old town of Pikeville, which flourished in the days before the coming of the railroads. After travelling as far as we could over a rough mountain road we left the car and walked over to Dugan Creek, a small stream that has cut its channel through sandstone beds, which form cliffs and overhanging ledges along its course. On the rocky banks and along the cliffs I noted *Fagus grandifolia*, *Magnolia acuminata*, *M. macrophylla*, *Rhododendron alabamense*, *Corylus americana* and *Tsuga canadenis*, a curious mixing of northern and southern species. The Hemlock is locally abundant here and some of the trees are of a large size. It has been recorded from several other stations in Alabama by Dr. Harper and others. Ferns were abundant, the

following species were noted and collected here: *Osmunda Claytoniana*, *Thelypteris noveboracensis*, *Adiantum pedatum*, *Asplenium pinnatifidum* and *Trichomanes Boscianum*. Several colonies of the *Trichomanes* were found under the overhanging ledges of sandstone where the surface was kept permanently wet by seeping water and where direct sunshine penetrated only for a brief time each day. The fern-like moss, *Fissidens polypodioides*, was growing very luxuriantly with the fern, as well as several other mosses and liverworts.

Holly Springs, Miss., April 22nd.

We drove back several miles this morning to investigate some thickets of *Crataegus* that we noticed yesterday evening, but which we did not then stop to examine on account of the rain. The hills here are calcareous, underlaid with a soft Cretaceous limestone, and *Crataegus* is rather abundant. We stopped at two localities between this place and the little town of Mooresville and found what I take to be *C. tersa*, *C. macra*, *C. frugiferens*, *C. amnicola*, *C. biltmoreana* and *C. apiifolia*, the last growing in low ground along a creek. A species of the *Crus-galli* group was also abundant. It is a small, moderately spiny tree, with slightly villous branchlets and corymbs. It was in full bloom and I secured good specimens, but do not recognize it and suspect that it may be an undescribed species. *Malus angustifolia* was also common and in full bloom in the thickets, and I also found here the little Adder's tongue *Ophioglossum Engelmannii*. Along the banks of the creek near Mooreville the *Malus* was also abundant, and I found *Castanea pumila*, *C. dentata*, *Amelanchier canadensis* and *Rhododendron canescens* var. *subglabratum* along the same stream.

Going back through Tupelo we turned aside to visit a Negro Industrial School, near Okolona, in which the father of my travelling companion had long been interested. We found the wife of the president in charge, apparently a very capable and energetic woman. After visiting several of the buildings, including class rooms, shops and the president's house and seeing the students at lunch in the dining hall, we took a hasty departure, favorably impressed by the rather pathetic, though heroic effort being made to carry on the difficult work of Negro education here with inadequate equipment and in the face of local indifference and hostility.

Between Tupelo and Okolona there is some botanically interesting country. The soft marly limestone comes to the surface in many places, and large fossil oyster shells are abundant. *Crataegus Ashei* is frequent in the thickets as well as the unknown *Crus-galli* species seen near Mooreville. A patch of *Cercis canadensis*, in

which the plants were all shrubby and not more than 2–3 m. tall, had the leaves more than half grown but still retained clusters of flowers on many of the branches.

Sikeston, Mo., April 23rd.

After crossing the Mississippi at Memphis this morning we followed the highway which is built through the wide alluvial valley, making our first stop north of the town of Marion, Arkansas. *Crataegus* trees in full bloom in the low partly cleared woods attracted out attention. On investigation they all proved to be *C. viridis*, which is one of the commonest species of the valley, ranging from the Gulf to northeastern Missouri. I also collected here *Quercus prinus*, *Ulmus crassifolia* and *Ilex decidua*, which last was in bloom and with leaves nearly fully grown but retaining a full crop of bright red berries from the previous year. I remember having found it similarly retaining the fruit a few years ago, near Salisaw, Oklahoma, and from specimens in the herbarium of the Arboretum it would seem that this is not unusual in the southern part of its range.

In the afternoon we made a stop in the lowlands of Pemiscot County, Missouri, near Hayti. Such typical species of the swamps and lowlands as *Taxodium distichum*, *Arundinaria macrosperma*, *Populus heterophylla*, *Planera aquatica*, *Catalpa speciosa*, *Fraxinus profunda*, *Forestiera acuminata* and *Bumelia lycioides* were growing here. *Catalpa* is fairly abundant and is native here. The southern *Bumelia* is rare so far north and I have only seen it at one other station in Missouri, near Neelyville, Butler County.

Cape Girardeau, Mo., April 24th.

This morning we crossed Crowley's Ridge, just west of the town of Campbell, Mo., and stopped for a few minutes to examine the flora. This remarkable bit of relief, surrounded on all sides by the lowlands of the valley, extends along the great river, which at one time is supposed to have flowed to the west of it, from Stoddard County, Mo., to Helena, Ark., some fifty miles below Memphis. In places it rises to a height of more than 100 meters above the surrounding lowlands. The formation consists largely of unconsolidated beds of sand, gravel and clay, with loess becoming more common towards the southern end. It was originally and still is in many places covered with a forest of deciduous trees, including several eastern species which reach their western limit here, and with a flora, rich both in woody and herbaceous species, and very different floristically from that of the surrounding country. Conifers and *Ericaceae* are almost entirely absent, although I remember

seeing a few trees of *Pinus echinata* that had invaded the gravelly hills near Jonesboro, Ark., and the Tree Huckleberry, *Vaccinium arboreum*, is found rarely in the same vicinity. Several species of Oaks, Hickories, Black and Sweet Gum, Beech, Tulip-tree, Elms, Maple, Linden and Ash are the commonest forest trees, with several species of *Prunus*, *Crataegus*, *Malus*, *Viburnum*, *Hydrangea* and other shrubs as undergrowth or in more open places.

The only thing of especial interest found at this place today was a *Crataegus* that may be a hybrid between *C. viridis* and a species of the *Crus-galli* group.

Later in the day we stopped in the outskirts of Poplar Bluff to have a look at *Quercus coccinea* var. *tuberculata*, which with the typical form is found locally on the gravelly hills.

Fredericktown, Mo., April 28th.

Leaving our camp at Cape Girardeau this morning we stopped to examine a bit of low swampy woods, about two miles east of Delta and just before crossing into Bollinger County. This is a remnant of the fast disappearing dense and luxuriant forest of typical coastal plain composition, that formerly covered the lowlands and swamps of this part of the Mississippi valley, extending as far north as the mouth of the Ohio and the Wabash rivers. Lumbering, clearing and drainage have made rapid inroads, and almost the last vestiges of it seem doomed to disappear as the region is being rapidly transformed into a fertile farming section. I have been particularly interested in trying to trace the northern boundaries of this lowland forest and the limits of some of the typical species, where they touch upon the foot-hills of the Ozarks and suddenly disappear.

The forest here had been lumbered some years ago and the land partly drained, but water stands upon much of it in rainy seasons and a second growth is springing up rapidly. The Pumpkin Ash (*Fraxinus profunda*) was common here but nearly every tree had been cut for lumber. Sprouts about the stumps are already beginning to bear fruit. Other common species are *Populus heterophylla*, *Quercus prinus*, *Q. lyrata*, *Q. palustris*, *Q. rubra*, *Carya laciniosa*, *Liquidambar Styraciflua*, *Gleditsia aquatica*, *Fraxinus pennsylvanica* var. *lanceolata*, *Acer rubrum*, *Itea virginica*, *Cornus femina* and *Cephalanthus occidentalis*.

We began this morning by having a puncture while going over a piece of road newly surfaced with coarse gravel, and on account of the rough going we did not discover it until the tube was ruined. This afternoon we got the car mired in trying to straddle a mud hole and spent a couple of hours extricating it, which we did only after

carrying quantities of flat rocks from a hillside to build up as we pried the wheels out, since it was impossible to use the jack. This took so long that by the time we had the car out and loaded again it was too late to go over to the interesting hills, which here form the extreme northern end of Crowley's Ridge, and which I had hoped to photograph. However, we climbed one of the nearest and examined the flora. This is close to the little town of Perkins, Scott County. The hills, rising abruptly from the surrounding lowlands here have a remarkable appearance, made more striking by the fact that while the bottoms have been mostly cleared for cultivation, these ridges are still heavily wooded. Many of the Beech, Oak, Hickory and other trees attain a large size. I photographed one large specimen of Beech and a King-nut tree, the trunks of which had grown together, apparently forming two halves of a composite trunk, for several feet above the base. This is the only part of Crowley's Ridge where I have seen outcrops of stratified rock, the usual gravel and clay deposits here having covered some remnants of the hard Ordovician dolomite, which is being excavated by erosion and is beginning to appear as cliffs and ledges in a few places.

Hugo, Okla., May 26th.

Our camp last night was in a beautiful and rugged part of the Ozarks, a few miles from the little town of Talihina, Oklahoma. After breakfast this morning I started out for a walk of several miles over the steep dividing ridges and deep hollows that, viewed from a high point, extend as far as can be seen in all directions. The prevailing geological formation is Pennsylvanian sandstone, varying greatly in stratification and density at different places. Most of the country is still heavily wooded with a mixed forest of Pine (*Pinus echinata*) and deciduous species of Oaks and Hickories prevailing on the ridges, and many other trees and shrubs along escarpments and ravines and in the deep narrow valleys. Some of the species found in such places are *Juniperus virginiana*, *Castanea ozarkensis*, *Quercus borealis* var. *maxima*, *Q. Shumardii* var. *Schneckii*, *Ulmus alata*, *Nyssa sylvatica*, *Amelanchier canadensis*, *Acer rubrum*, *A. saccharum*, *Cornus obliqua*, *Vitis aestivalis* and *V. rupestris*. Along the rocky margins of a mountain creek I also collected *Carpinus caroliniana*, *Rubus flagellaris*, *Ceanothus ovatus*, *Hypericum oklahomense*, *Mitchella repens*, *Amorpha fruticosa* and another species of *Amorpha*, somewhat resembling *A. glabra*, but with slightly pubescent foliage and branches, which I do not recognize.

In places along moderate slopes hard beds of the sandstone come to the surface, forming glades or barrens, conspicuous in the

forest for the absence of trees. I stopped to examine and to take some photographs in one of these, which was several acres in extent. Conspicuous amongst the large number of herbaceous species here were *Cheilanthes lanosa*, *Camassia esculenta*, *Delphinium azureum*, *Talinum teretifolium*, *Tephrosia virginiana*, *Tragia nepetifolia*, *Ptilimnium Nuttallii*, *Spermolepis echinata*, *Opuntia humifusa*, *Hedeoma hispida*, *Kneiffia linifolia*, *Pentstemon arkansanus*, *Ruellia ciliosa*, *Specularia leptostachya*, *Coreopsis grandiflora* (not yet in bloom), *Thelesperma trifidum*, *Echinacea angustifolia* and *Krigia occidentalis*.

In the afternoon I stopped along a little creek near the village of Finley to photograph some fine blooming specimens of *Yucca arkansana*. A little further on, along the bluffs and banks of Mill Creek, I collected *Tilia floridana*, *Chionanthus virginica*, *Castanea ozarkensis*, and *Amorpha nitens*. A few miles farther south, near Kaimichi, along the bed of a little mountain creek, I found *Salix petiolaris*, *Andrachne phyllanthoides*, and a curious and unknown form of Witch Hazel. This seems to be quite an extension southward of the known range of *Salix petiolaris*, which was previously known from Canada to northeastern Missouri.

The *Hamamelis* is evidently closely related to the spring-blooming species, *H. vernalis*, which is so abundant along the rocky streams of the Ozark region. Although the plants here are smaller than the average for *Hamamelis vernalis*, they have the characteristic stoloniferous habit of that species as well as the rather thick upright leaves of similar type. A form of this species, with slightly tomentulose branches and leaves more or less pubescent along the veins beneath, has been described by Mr. Alfred Rehder as *Hamamelis vernalis* forma *tomentella* †. The type specimen of this form came from Potean, Oklahoma, which is in the same general regions as Kaimichi, and it is also in cultivation at the Arnold Arboretum. However, the Kaimichi plants are so different not only from the typical form of *Hamamelis vernalis* but also from the forma *tomentella* that they can scarcely be regarded as a mere form and be referred to the latter. The leaves are thickly coated beneath with a persistent close felty pubescence, often tawny or reddish along the petioles and veins, and with scattered grayish stellate hairs on the upper surface. The branchlets are also copiously villous-tomentose.

In the original description of *Hamamelis vernalis*[1] Professor Sargent states that the leaves are either glabrous or stellate pubescent on both surfaces, and specimens that he has noted as included in his type material scarcely differ from the type specimen of the

[1] Sargent, Trees and Shrubs, II. 137 (1911).

forma *tomentella*. The foliage of the plants found near Talihina is so different that they appear more distinct than any American species that has been distinguished since the publication of *Hamamelis virginiana*. But since a name has already been given to a tomentulose form of *H. vernalis*, to which this plant is clearly related and since it is likely that other intermediates will be found it is perhaps best to regard all of the tomentose forms as one variety, and I am therefore calling the pubescent plants *Hamamelis vernalis* var. *tomentella*.[1]

About Antlers, Oklahoma, the soil of the uplands is extremely sandy. *Quercus cinerea* grows in such soil, and I found it near here several years ago, but did not see it today. *Crataegus pilifera* is growing here as a small tree 4–5 m. tall, and *C. uniflora* as a slender shrub scarcely a meter tall, but in abundant fruit. *Jatropha texana*, *Lithospermum Gmelini* and *Pentstemon pauciflorus* were also collected in the sandy open woods.

As we approached Hugo there was a marked change in the character of the country and in the flora. Cretaceous limestone comes to the surface in many places and the soil resulting from it is a stiff black gumbo, which is quite fertile, as shown by the better quality of farm improvements and other evidences of prosperity. Woods are confined largely to the vicinity of the streams, with broad stretches of upland prairie, and glades are frequent on limestone outcrops. *Maclura pomifera* is native here, and the little wild Rose *Rosa foliolosa* is abundant. There is also a great profusion of wild flowers in rainy seasons. *Pentstemon Cobaea*, and *Petalostemon albidus* are conspicuous and I also collected the little suffrutescent *Phyllanthus polygonoides*.

Stillwater, Okla., May 28th.

We pitched our tent last night along a pretty little stream, Pennington Creek, near Tishomingo, the county seat of Johnston County and formerly the capitol of the Chickisaw Indian tribe. There is an outcrop of granite in this section, and the creek has cut its channel through the hard igneous rocks, great masses of which lie scattered about, piled up and eroded into the most

[1] **Hamamelis vernalis** var. **tomentella** (Rehder), comb. nov.

Hamamelis vernalis f. *tomentella* Rehder in Jour. Arnold Arb. 1. 256 (1920).

A typo differt foliis supra stellato-pubescentibus, infra glaucescentibus dense stellato-pubescentibus; petiolis nervisque fulvo-pubescentibus. Ramuli juveniles dense fulvo-stellato-pubescentes.

Near Kaimichi, Pushmataha County, Oklahoma, *E. J. Palmer*, no. 39394, May 26, 1931.

The plant here described differs from the form distinguished as f. *tomentella* in being densely felty-tomentose on the under surface of the leaves instead of sparsely stellate-pubescent, and also in the more densely pubescent young branchlets.

fantastic shapes. The locality bears the rather sinister name of the "Devil's Den," and it is much frequented as a summer resort and by campers and fishermen. There is considerable small timber along the creek and in the more rugged or more protected places amongst the granite, but over considerable areas where unbroken beds of the rock come to the surface, trees and shrubs are absent and only small colonies of peculiar herbaceous plants grow in the slight depressions where thin deposits of soil have accumulated and where water stands for some time after rains. In some of the larger depressions there are permanent pools and small ponds. *Juniperus virginiana*, *Juglans nigra*, *Carya Buckleyi* var. *arkansana*, *Quercus stellata*, *Q. Muhlenbergii*, *Q. macrocarpa*, *Q. velutina*, *Q. Schneckii*, *Q. marilandica*, *Ulmus americana*, *U. alata*, *Celtis laevigata* var. *texana*, *C. reticulata*, *Maclura pomifera*, *Prunus lanata*, *Cercis canadensis*, *Sapindus Drummondii* and *Bumelia lanuginosa* are some of the commonest trees, with *Yucca arkansana*, *Rubus ostryifolius*, *Rhus glabra*, *R. copallina*, *R. Toxicodendron*, *R. trilobata*, *Ilex decidua*, *Lonicera albiflora* var. *dumosa* and a few other shrubby species occupying most of the area. Vines are abundant in the woods and amongst the protecting rocks. The following climbing or trailing species were seen: *Smilax hispida*, *S. Bona-nox*, *Cebatha carolina*, *Aristolochia tomentosa*, *Vitis cordiformis*, *V. vulpina*, *Cissus incisa* and *Melothria pendula*.

Confined to the margins of the stream are *Salix nigra*, *S. longipes* var. *Wardii*, *Populus deltoides*, *Alnus maritima*, *Platanus occidentalis*, *Amorpha fruticosa* and *Acer Negundo*. The *Alnus* is very abundant and grows in large clumps, some of the plants being 5–6 m. tall. This species was first found along the Atlantic coast in southern Delaware and Maryland, and is only known in that section and in a small area here in south-central Oklahoma. It seems hard to explain this curious distribution as the two regions are so remote and so dissimilar in many respects.

The Woolly Lipfern (*Cheilanthes tomentosa*) is abundant in the clefts of the granite and *C. lanosa*, *Woodsia obtusa*, *W. oregana*, *Asplenium resiliens* and *A. Trichomanes* were also collected here. *Sedum Nuttallianum* is dominant and almost the only plant over small patches of thin soil in shallow depressions of the granite. *Clinopodium glabrum*, *Froelichia gracilis*, *Crotonopsis ovata* and *Plantago Purshii* are other plants common in the glades, and in somewhat heavier soil *Gaillardia pulchella* is very abundant.

Herbarium, Arnold Arboretum
Harvard University.

PARASITISM OF MYXOMYCETE PLASMODIA ON FUNGOUS MYCELIA

FRANK L. HOWARD[1] AND MARY E. CURRIE

With plate 54

TO FURTHER the general thesis that the Myxomycetes play a rôle in the consumption of fungi which cause wood decay, the digestion and assimilation of the mycelia of chiefly lignicolous fungi by plasmodia was studied after the parasitism of the plasmodial stage of several Myxomycetes upon mushrooms and polypores had been demonstrated (5). Enlightenment upon the problem was sought by observation of the habits of plasmodia in the forest and also by laboratory tests of the feeding habits of plasmodia on pure cultures of numerous fungi. This study has brought to light the mycophagous habit in several species of Myxomycetes, in addition to those already reported (5), and has disclosed a wide range of fungous mycelia capable of being digested by plasmodia.

RELEVANT LITERATURE

The digestion of the mycelia of fungi by slime molds has, with but one or two exceptions, been reported only incidentally by investigators in connection with their study of some other phase of the biology of the group. The work of A. Lister (6) gives us some excellent notes on the behavior of the plasmodium of *Badhamia utricularis*, but only the reaction of the plasmodium to the mycelium of a chance, unidentified fungus was observed. Hilton (3) cultivated *B. utricularis* upon moist bread and he observed that the hyphae of various species of *Aspergillus* and *Penicillium*, which developed on the bread, were dissolved and absorbed by the plasmodium.

Physarum nutans has been credited by Elliott and Elliott (2) with the absorption and destruction of the mycelia of *Bulgaria polymorpha* and *Coryne sarcoides* within the wood of an oak branch. Sanderson (7) frequently encountered *Physarum auriscalpium* Cooke upon the mycelium of *Sphaeronema fimbriatum* which rots tapped surfaces of *Hevea; Physarum reniforme* Lister on the dead cortex of *Hevea* attacked by *Ustulina zonata;* and *Arcyria denudata* Wettst. associated with *Sphaerostilbe repens* in Malaya on fuel heaps of split timber and on small diseased roots of *Hevea.* One cannot read Sanderson's paper without feeling that the plasmodia of Myxomycetes may parasitise fungi responsible for the decay of wood.

[1] Fellow of the National Research Council, 1930–1932.

Skupienski (9) describes the plasmodium of *Didymium difforme* feeding on *Aspergillus glaucus*, *Sterigmatocystis* sp., *Penicillium* sp., *Stysanus* sp., and various other molds, yeasts, and bacteria. He also found that the plasmodium of *Didymium nigripes* would digest the hyphae of *Penicillium* (8). On the other hand, Celakovsky (1) working with *Chondrioderma* (*Didymium*) *difforme* Rost. reported plasmodia as non-mycophagous, since he observed plasmodia envelop spores and hyphae of *Penicillium glaucum*, *Mucor stolonifer* and *Phycomyces nitens*, and later relinquish them unharmed.

MATERIALS AND METHODS

The plasmodia used in these studies were collected in the forest and brought into the laboratory for cultivation on media, or were cultivated directly from spores (4). The cultures of fungi employed were either isolated by the authors or obtained through the generosity of other workers, especially Dr. Irene Mounce and Dr. C. L. Shear.

In the earlier trials (Tables 1 and 2), in order to test the parasitism of plasmodia, petri plates of nutrient agar were inoculated in the center with the fungus being tested, which was allowed to grow until the colony covered about one-half the diameter of the dish before a bit of plasmodium, previously freed from contaminating fungi, was transferred to the culture. The various standard nutrient agar media used for the culture of the fungi included rolled oat, ground corn, ground corn and dextrose, malt extract, and potato dextrose.

In later trials (Table 3), the senior author devised the following technique: using a sterilized instrument, a disk about one centimeter in diameter is cut from the center of a layer of two per cent plain agar in a petri plate (Plate 54, fig. 1) and in the vacancy is inserted a similar disk of nutrient agar upon which the test fungus is growing. When the fungous hyphae grow from the nutrient agar disk into the plain agar, a piece of plasmodium is introduced and its action toward the hyphae observed. This change in technique was made because in previous experiments where a nutrient substratum was employed and where the plasmodium very slowly digested the mycelium, it was difficult to ascertain whether the growth of the myxomycete was due to digestion of the fungus or to absorption of nutrients directly from the agar. In spite of repeated attempts, it was impossible to free certain of the plasmodia from bacterial contaminants, so here again, the non-nutrient, slightly acid agar substratum was an advantage, as it helped to inhibit the growth of bacteria. In the later trials the H-ion concentration of the agars was taken into account and was adjusted to pH. 6.0±0.3.

THE PARASITIC HABIT AND THE INFLUENCING FACTORS

In order first, to determine if the digestion of fungous hyphae by Myxomycetes is affected by the nutrients in different culture media, as has been reported for the consumption of some bacteria by plasmodia, and second, to find a favorable medium, the junior author made a few preliminary experiments in which fungi were grown on five different agar media, namely, potato dextrose, linseed, *Vicia*

TABLE 1.—PARASITISM OF PLASMODIA UPON FUNGI GROWING ON DIFFERENT MEDIA.

Fungus \ Myxomycete	Badhamia magna	Badhamia rubiginosa	Badhamia utricularis	Brefeldia maxima	Hemitrichia clavata	Leocarpus fragilis	Lindbladia effusa	Lycogala epidendrum	Physarum cinereum	Physarum flavicomum	Physarum polycephalum	Physarum virescens	Trichia decipiens
Corn Dextrose Agar													
1. Collybia velutipes	VP	—	—	P	P	—	VP	P	P	—	VP	P	P
2. Pleurotus ostreatus	VP	P	—	P	P	—	—	—	P	—	—	—	—
3. " serotinus	VP	P	—	P	P	—	—	—	P	—	—	—	—
4. Polyporus resinosus	P	N	—	N	P	—	—	—	P	—	—	—	—
Rolled Oat Agar													
1. Pleurotus serotinus	VP	P	—	—	—	—	—	—	VP	—	—	—	—
2. Polyporus resinosus	—	P	—	—	—	—	—	—	—	—	—	—	—
Potato Dextrose Agar													
1. Fomes applanatus	—	P	—	—	P	—	—	—	—	—	—	—	—
2. Pleurotus ostreatus	—	N	VP	N	N	—	—	—	—	VP	VP	—	—
3. " serotinus	—	N	VP	—	—	—	—	—	—	VP	VP	—	—
4. Polyporus resinosus	P	N	—	—	—	—	—	—	—	P	P	—	—
Linseed Agar													
1. Collybia velutipes	—	N	—	—	N	—	—	—	—	—	—	—	—
2. Fomes applanatus	—	N	—	N	—	—	—	—	—	—	—	—	—
3. Pleurotus ostreatus	—	P	—	N	—	VP	—	—	—	—	—	—	—
Vicia Faba Agar													
1. Fomes applanatus	—	—	—	—	—	—	—	—	VP	—	—	—	—
2. " fomentarius	N	—	—	—	—	—	—	—	—	—	—	—	—
3. " pinicola	—	—	—	—	—	—	—	—	N	—	—	—	—
4. Polyporus resinosus	N	—	—	—	—	—	—	—	—	—	—	—	—
5. Polystictus versicolor	VP	—	—	—	—	—	—	—	—	—	—	—	—

N—not parasitic, P—parasitic, VP—very parasitic.

Faba, rolled oat, and corn dextrose. Plasmodia were transferred to the plates in which the fungi were growing and the results of their parasitism on the mycelia are presented in Table 1. The relative terms used in Table 1 and in subsequent tables to describe the degree of parasitism of the myxomycete, based upon the criterion of the

rate of digestion of the fungous mycelium, are: "very parasitic," "parasitic" and "not parasitic." "Very parasitic" denotes a case in which the mycelium of the fungus was rapidly and usually completely consumed, as for example, the case of *Badhamia magna* on *Collybia velutipes*. Where "parasitic" is recorded, the mycelium was more slowly and usually not entirely consumed. "Not parasitic" is recorded when the mycelium was not digested, even though the plasmodium may have passed over it.

The incomplete data recorded in Table 1 indicate that a plasmodium cannot always attack the same mycelium when grown on a different medium, for example, *Badhamia rubiginosa* attacked and consumed the mycelium of *Pleurotus ostreatus* growing on corn dextrose agar but avoided the same fungus growing on potato dextrose agar. This would seem to indicate that the nature of the medium plays an important part in rendering the mycelium susceptible to attack by a plasmodium. It should be noted, however, that some species of fungi even on the same favorable medium and exposed to plasmodia capable of vigorous parasitism on other fungi, invariably remain unattacked. For example, *Physarum cinereum* avoided the mycelium of *Fomes pinicola* growing on *Vicia Faba* agar but did attack *Fomes applanatus* hyphae growing on the same agar. Examples further substantiating this principle are brought out in later experiments (Tables 2 and 3).

Table 2 shows species of plasmodia which consumed mycelia grown on corn dextrose agar. Petri plates containing this agar were inoculated with different fungi and when a considerable mycelium had developed, four or five cultures of each fungus were inoculated with a small piece of plasmodium. The plates were then incubated at 22° C. This work brings out many idiosyncrasies in the ability of the plasmodia to digest different species of fungi. Some slime molds appear to be generally parasitic upon fungous hyphae while others are only selectively so. The length of life of a plasmodium varied under the conditions of the test, but it was rarely longer than that of a healthy plasmodium growing on corn agar without the fungus.

Although the essential process of assimilation of fungous hyphae is the same for all myxomycetes on all kinds of mycelia, there is great variation in the extent to which and the manner in which hyphae are consumed as a plasmodium advances over a fungus colony (Plate 54, figs. 1–10). Sometimes a plasmodium, advancing across a mycelial culture, digests the mycelium with which it comes in contact and leaves a path freed from fungous hyphae, as does *Physarum polycephalum* on *Collybia velutipes*. Sometimes the plasmodium spreads out in all directions, exposing an ever-widening

circle of bare agar as it consumes the mycelium; such is true of *Trichia decipiens* Macbr. and *Lindbladia effusa* Rost. on *Daedalea confragosa*. And sometimes, if the mycelium is in a tough appressed layer, the plasmodium removes only the superficial hyphae, as for example, *Lycogala epidendrum* Fr. on *Lenzites betulina*.

TABLE 2.—PARASITISM OF PLASMODIA UPON FUNGI GROWING ON CORN DEXTROSE AGAR.

Fungus \ Myxomycete	Badhamia magna	Badhamia rubiginosa	Brefeldia maxima	Fuligo septica	Hemitrichia clavata	Leocarpus fragilis	Lindbladia effusa	Lycogala epidendrum	Physarum cinereum	Physarum flavicomum	Physarum polycephalum	Physarum virescens	Stemonitis fusca	Trichia decipiens
1. Collybia velutipes	VP	—	P	—	P	N	P	P	P	—	VP	P	N	P
2. Daedalea confragosa	VP	P	P	—	N	P	P	P	—	—	VP	N	—	P
3. Fomes applanatus	P	P	—	—	P	—	P	P	P	—	—	P	—	P
4. Fomes fomentarius	P	P	P	P	P	—	P	P	P	—	—	—	—	—
5. Fomes igniarius	VP	—	—	P	—	P	P	P	—	—	—	—	—	P
6. Fomes pinicola	N	—	—	—	—	—	—	—	N	—	—	—	—	—
7. Lentinus lepideus	P	N	N	—	P	P	P	P	—	—	P	N	P	N
8. Lenzites betulina	P	P	P	—	P	P	P	P	—	—	P	P	—	P
9. Pleurotus ostreatus	VP	P	P	P	P	P	P	P	P	P	VP	N	N	P
10. Pleurotus serotinus	VP	N	P	P	P	P	P	P	P	VP	VP	N	—	P
11. Polyporus resinosus	P	N	N	N	N	N	P	N	P	P	P	—	—	P
12. Polystictus nigro-marginatus	—	—	P	P	P	—	P	P	—	—	P	P	—	P
13. Polystictus versicolor	VP	—	—	—	—	—	—	—	—	—	VP	—	—	—
14. Polystictus sp.	P	N	—	—	—	—	P	P	—	—	P	—	—	P
15. Poria sp.	N	N	P	P	—	N	N	P	—	—	P	P	—	P
16. Trametes pini	P	N	P	P	P	N	P	P	—	—	P	P	—	P

N—not parasitic, P—parasitic, VP—very parasitic.

The parasitism of plasmodia on fungi growing on rolled oat agar was tried by the senior author with the following results: *Leocarpus fragilis* slowly consumed hyphae of *Monilia* (*Neurospora*) *crassa* and of a *Penicillium* sp. *Physarum polycephalum* rapidly digested the mycelium of *Alternaria* sp., *Aspergillus* sp., *Cyathus stercoreus*,

TABLE 8.—PARASITISM OF PLASMODIA UPON FUNGI GROWING ON DISKS OF OAT AGAR INSERTED IN PETRI PLATES OF PLAIN AGAR.

Fungus	Myxomycete	Arcyria occidentalis	Badhamia rubiginosa	Fuligo septica	Hemitrichia Vesparium	Physarum polycephalum	Physarum tenerum	Trichia persimilis	Trichia scabra	T	BFU	BH	BI	BJ	BX	HH	C14	C16	C30
1. Armillaria mellea		N	—	P	P	VP	VP	P	P	P	VP	P	—	P	P	VP	P	P	VP
2. Bulliardella sp.		N	—	—	—	VP	VP	—	—	—	—	—	—	N	—	—	—	—	—
3. Collybia velutipes		N	N	N	VP	VP	VP	—	N	N	VP	P	N	N	P	N	N	N	N
4. Coprinus micaceus		VP	N	P	P	VP	VP	N	VP	N	N	VP	N	N	P	P	N	N	N
5. Crucibulum vulgare		N	N	N	N	VP	VP	—	N	N	VP	—	N	N	N	N	N	N	N
6. Daldinia concentrica		N	—	N	P	VP	—	—	—	—	—	—	—	VP	—	—	P	VP	—
7. " occidentalis		VP	—	VP	P	VP	—	—	—	—	—	—	—	VP	P	VP	VP	N	—
8. " simulans		N	—	P	P	VP	—	—	—	P	—	—	—	—	VP	P	P	VP	—
9. " vernicosa		—	—	VP	—	P	—	—	VP	P	—	—	—	—	P	VP	—	VP	—
10. Fomes applanatus		N	—	N	N	VP	P	—	N	P	VP	—	—	N	N	N	N	N	—
11. " fomentarius		N	—	P	N	VP	P	—	N	N	VP	N	—	N	N	N	N	N	—
12. " igniarius		P	N	P	P	VP	VP	—	N	N	VP	N	N	—	P	P	P	N	—
13. Ganoderma oregonense		N	N	N	N	P	N	—	N	N	N	N	N	N	N	N	N	N	N
14. Hypoxylon coccineum		N	—	VP	VP	P	—	—	—	N	—	—	—	N	N	P	P	P	—
15. Lentinus lepideus		N	—	N	N	VP	VP	—	—	N	N	—	—	N	N	N	N	N	N
16. Lenzites saepiaria		N	—	P	N	VP	VP	P	N	N	VP	VP	N	VP	N	N	VP	N	—
17. Mycorrhizal fungus		—	—	—	—	VP	P	—	—	P	—	—	—	—	—	—	—	—	—
18. Mytilidion sp.		P	—	—	N	VP	VP	—	—	—	P	—	—	—	N	N	—	—	—
19. Panus stipticus		VP	N	P	P	VP	VP	—	N	N	—	—	N	N	P	P	P	N	—
20. Pholiota adiposa		N	P	P	N	VP	VP	—	N	N	VP	—	N	N	N	N	N	P	—
21. Pleurotus ostreatus		N	—	N	N	VP	VP	—	N	N	VP	N	—	N	N	N	—	N	—
22. Polyporus betulinus		P	—	VP	P	VP	VP	N	N	N	VP	—	N	N	N	P	P	N	—
23. Polystictus pargamenus		N	N	N	N	VP	VP	N	N	N	VP	N	N	N	N	N	N	N	—
24. " versicolor		N	N	P	N	VP	VP	—	N	P	VP	N	—	N	N	P	N	N	N
25. Schizophyllum commune		N	N	N	N	VP	VP	N	N	—	VP	P	N	N	N	N	N	N	N
26. Trametes pini		N	—	N	N	VP	VP	—	N	P	VP	N	N	N	N	N	—	N	N

N—not parasitic, P—parasitic, VP—very parasitic.

Exidia glandulosa, *Merulius americanus*, *Monilia* (*Neurospora*) *crassa*, *Nidularia pulvinata*, *Penicillium* sp., *Tremella mesenterica*, and *Tremella* sp.; but did not digest the hyphae of *Beauveria globulifera*, *Guepinia spathularia*, and *Mucor* sp. *Physarum viride* plasmodia rapidly digested the mycelium of *Chaetomidium fimeti;* and more slowly digested hyphae of *Aspergillus* sp., *Beauveria bassiana*, *Monilia* (*Neurospora*) *crassa*, and a species of *Penicillium*.

A wide range of species of fungous mycelia capable of being digested by various plasmodia was tested by the disk insertion method (Plate 54, fig. 1), and the results are tabulated in Table 3. Occasionally cultures exhibited a puzzling variation in the digestion of the mycelium on oat agar disks and to obviate this, duplicate cultures were prepared. Indeed, in some instances to give added certainty, if the duplicate cultures showed any discrepancy, three to four additional cultures were made. In such doubtful cases, it is the average behavior of three to five plasmodia that is recorded in Table 3. The variation, however, was generally a question of the rate of digestion of the mycelium by the plasmodium. For instance, *Arcyria occidentalis* slowly consumed the mycelium of *Fomes igniarius* in two trials while in a third trial the plasmodium completely digested the mycelium, but in Table 3 this plasmodium is listed merely as "parasitic" instead of "very parasitic." Likewise, out of five trials of *Physarum tenerum* on *Fomes fomentarius*, three gave evidence of parasitism while the other two did not, yet the plasmodium is listed as "parasitic." As previously stated, the variation was commonly one of the degree of parasitism with but one or two exceptions. One exception occurred in the case of *Fuligo septica* digesting *Lentinus lepideus*, in which the plasmodium died on the mycelium in two cultures, avoided the mycelium in a third, but completely consumed it in a fourth.

The fungus listed as "mycorrhizal fungus" (see Table 3), is a subculture of *Mycelium radicis atrovirens* isolated in Sweden by E. Melin and obtained through the courtesy of Mr. A. B. Hatch. This non-sporulating fungus produces a dark submerged mycelium and a lighter aerial mycelium which was consumed by *Physarum polycephalum*, *Physarum tenerum*, and slightly by plasmodium T.

The behavior of the plasmodia in digesting fungous mycelia seems unquestionably to vary with the medium upon which the fungi are growing. The plasmodia of *Physarum tenerum* and *Physarum polycephalum* more rapidly consumed the mycelium of *Schizophyllum commune* from disks of malt extract agar than from disks of rolled oat agar. Another, more striking example, of the effect of the medium upon the ability of a plasmodium to digest a given

mycelium was demonstrated by *Hypoxylon coccineum*. This fungus is very slowly digested on oat agar by the plasmodium of *Physarum polycephalum*, while in repeated trials the same fungus growing on bean pod decoction agar is rapidly consumed by the same myxomycete. It is of interest to note that on the first medium a dark green pigment is produced by the fungus while on the second it is absent, but whether the presence or absence of this pigment is in any way connected with susceptibility to parasitism remains a question. Similarly, a yellow undetermined species (Plasmodium T) digested the white aerial hyphae of *Hypoxylon coccineum* from a disk of bean pod agar but not from a disk of oat agar.

In summarizing the parasitism of plasmodia and the factors influencing it, Tables 1, 2, and 3 demonstrate that the same plasmodium may flourish on the mycelium of one fungus and not attempt to attack that of another species. Plasmodia of the same genus but of different species of slime mold may show as great a variation in parasitism as those of two different genera. In general, it may be said that some Myxomycetes are restricted in choice of host while others seem to be generally mycophagous.

SUMMARY

Laboratory and field observations have disclosed the mycophagous habit of several plasmodia of Myxomycetes other than the fifteen species that the authors (5) recently reported digesting Hymenomycetes, which furthers the hypothesis that plasmodia digest the mycelia of a wide variety of fungi responsible for the decay of wood and debris. The Myxomycetes found to consume fungous hyphae under the conditions of the tests were: 1, *Arcyria occidentalis*, 2, *Badhamia magna*, 3, *B. rubiginosa*, 4, *B. utricularis*, 5, *Brefeldia maxima*, 6, *Fuligo septica*, 7, *Hemitrichia clavata*, 8, *H. Vesparium*, 9, *Leocarpus fragilis*, 10, *Lindbladia effusa*, 11, *Lycogala epidendrum*, 12, *Physarum cinereum*, 13, *P. flavicomum*, 14, *P. polycephalum*, 15, *P. tenerum*, 16, *P. virescens*, 17, *P. viride*, 18, *Stemonitis fusca*, 19, *Trichia decipiens*, 20, *T. persimilis*, and 21, *T. scabra*.

Two methods for testing the parasitic habit were used: one, in which the plasmodia were allowed to attack the fungi on the same nutrient medium upon which the latter were growing, and a second, in which the plasmodia were transferred to petri plates of plain agar, each having an inserted disk of nutrient agar upon which the fungus was growing (Plate 54, figs. 1–2). The mycelia of forty-nine, chiefly wood-inhabiting fungi were tested and were found to be consumed in varying degrees by plasmodia.

Before closing, the junior author wishes to express her thanks to

Professor J. H. Faull for the direction and the advice given during the progress of her work which was carried on at the University of Toronto during 1919–1921. The senior author takes this opportunity to thank Professor J. H. Faull for making possible the joint publication of the observations made independently by the authors, Professor W. H. Weston, Jr., for his interest and counsel given, and the Board of Fellowships in the Biological Sciences for a grant which made this work possible.

LABORATORIES OF CRYPTOGAMIC BOTANY
HARVARD UNIVERSITY

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9. ————. Badania Bio-cytologiczne nad Didymium difforme Duby, czesc pierwsza. (Acta Soc. Bot. Poloniae, **5**: 255–336, pls. 12–18. 1928.)

EXPLANATION OF PLATE 54

Fig. 1. Plasmodium of *Physarum polycephalum* leaving the transferred piece of agar and moving toward the mycelium of *Trametes pini* growing on an oat agar disk which has been inserted in a petri plate of plain agar. Six hours later the fungous hyphae had been completely consumed. × ½.

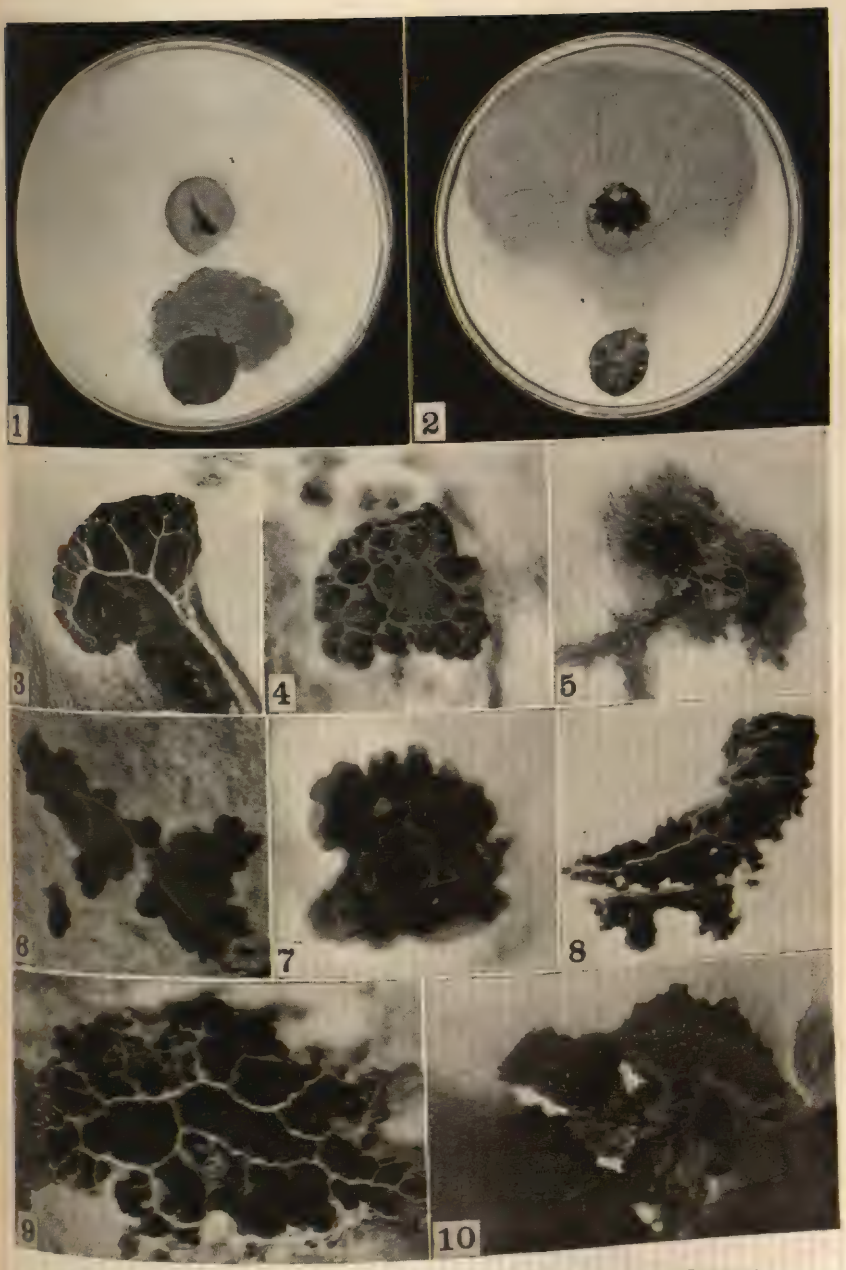
Fig. 2. Plasmodium of *P. polycephalum* consuming the white hyphae of *Fomes igniarius* from an oat agar disk and leaving some of the older dark-colored hyphae.

Fig. 3. Plasmodium of *Physarum virescens* digesting the hyphae of *Fomes applanatus* on corn dextrose agar.

Fig. 4. Plasmodium of *Badhamia rubiginosa* removing the mycelium of *Daedalea confragosa* from corn dextrose agar.

Fig. 5. Plasmodium of *Fuligo septica* dissolving *Fomes fomentarius* hyphae on corn dextrose agar.

Fig. 6. Plasmodium of *Brefeldia maxima* attacking hyphae of *Collybia velutipes*.



Parasitism of Myxomycete Plasmodia on Fungus Mycelia

Fig. 7. Plasmodium of *Brefeldia maxima* parasitizing the mycelium of *Daedalea confragosa* on corn dextrose agar.
Fig. 8. Plasmodium of *Lycogala epidendrum* attacking the hyphae of *Daedalea confragosa*.
Fig. 9. Plasmodium of *Trichia decipiens* removing the mycelium of *Daedalea confragosa* from corn dextrose agar.
Fig. 10. Plasmodium of *Badhamia magna* consuming the hyphae of *Fomes applanatus*.

NOTES

The Arnold Arboretum during the Fiscal year ended June 30, 1932.

Climatically the year 1931–32 proved generally favorable to the growth and well-being of the collections. On February 4th, however, there was a heavy fall of snow that adhered to the trunks and limbs of trees and burdened shrubs and coniferous foliage with a thick mantle of white. Although the landscape effect was exceptionally beautiful in the Arboretum, much damage was done and several weeks had to be devoted to the pruning necessary to remove injured branches. In the spring the rainfall was plentiful and adequately supplied the needs of the plants for moisture. The Cherries and Rhododendrons produced an abundance of flowers and were exceptionally fine.

Now and again, usually through the unintentional carelessness of visitors, fires break out in the arboretum and threaten injury or destruction to valuable specimens. In the spring of 1932, several serious fires, a few doubtless of vandalistic origin, caused distressing damage. One of these menaced Hemlock Hill on April 30th, and before it was finally checked, had destroyed a plantation of Japanese Yews. It is evident that fire is an evil that must be controlled by the most efficient means if the work of years is not to be undone in a few minutes and losses incurred that can never be made good.

We continued our exchanges of plants, cuttings, grafts and seeds and during the year there were sent out 833 cuttings and grafts; 1997 plants and 941 packets of seeds. There were received from other institutions, 1666 plants, cuttings and grafts and 294 packets of seeds.

The publications of the Arboretum, the Journal and the Bulletin of Popular Information, were issued with customary regularity. Of the more than four hundred periodicals, bulletins and reports that come to the Library from all parts of the world, we receive 225 in exchange for our publications. In June the first issue of the new series to be known as Contributions from the Arnold Arboretum appeared, being The Hypodermataceae of Conifers

by Grant Dooks Darker. The second number of the Contributions is in the Press and the third number is under preparation and should be issued in 1933.

One thousand, one hundred and sixty-eight visitors registered at the Administration Building. They came from thirty-one of the United States, from Canada, China, Hawaii, Ireland, England, Egypt, and West Africa.

The "Harvard Experiment Station" situated near the city of Cienfuegos in Cuba, was originally associated with the Botanic Garden of the University under the supervision of the Director. It was founded by Mr. E. F. Atkins of Boston for the purpose of carrying on investigations looking toward the improvement of the varieties of sugar-cane and with the intention of assembling there a representative collection of tropical plants. As the enterprise became more and more closely associated with applied biology, it was transferred to the Bussey Institution of Applied Biology. Early in 1932, the Corporation voted to transfer the Station to the Arnold Arboretum with the title, "Atkins Institution of the Arnold Arboretum." In this regard it is worthy of note and record, that in 1926, Professor Sargent had looked favorably on a proposal to place the Cuban Station under the general control and management of the Arnold Arboretum and had assigned to Professor Jack the task of making a representative collection of the woody plants that grow in the vicinity of Cienfuegos. In recent years, Professor Jack has visited the Institution frequently and has given close attention to the introduction of Cuban woody plants to the living collections, while diligently working on the formation of an herbarium comprising the flora of the surrounding country.

At the end of this report there is appended a bibliography covering the publications of the staff and their students for the year ending June 30th, 1932. This bibliography indicates very clearly the wide extent and varied nature of the investigations that are receiving the attention of the Arboretum.—O. A.

Pathological Laboratory.—The Laboratory in Plant Pathology submits its report for 1931–2, making reference to improved facilities for investigation, extension service and research activities.

Pathological collections constitute an important equipment of our laboratory because they afford both subject matter for study and specimens for reference. Therefore, a consistent effort has been made to add to the materials required for a more comprehensive solution of our immediate research problems, and such as may be useful by way of illustration of as wide a range as possible of plant diseases comprised within the scope of our special field.

Liberal contributions have been received from correspondents, others have been obtained by exchange and many have been collected by members of the staff. Of the last named particular mention should be made of extensive accessions from Europe and America through G. D. Darker and from the western States and New England through J. H. Faull; the former are rich in "needle cast" fungi, the latter in coniferous rusts. Pertinent to this subject I am pleased to report a closer contact with the Farlow Library and Herbarium, recently initiated by the appointment of Arboretum representation on the Administration Board of that institution.

A second step forward in reference to improved facilities is the provision of laboratory accommodation made by the Corporation of Harvard University for research students working on the pathology of woody plants. While the Arboretum does not enroll research students nor regard itself as responsible for the financial support of their work, it does freely and gladly place its rich stores of plants and literature at their disposal, and offers direction in their investigations. Heretofore the students in pathology at the Arboretum have found laboratory space wherever made available through the courtesy of other departments. We now happily record appreciation of the splendid provision made for them in the new Biological Laboratories. They now have their own apparatus and laboratories, and at the same time they enjoy the distinct advantages of being in the centre of the scientific life of the University. During the year six of these research students have been cared for in the new quarters.

Each year brings its quota of requests from far and near for information on the diseases of forests and ornamental trees and shrubs, and the past year has been no exception in this respect. Many of these requests concern known troubles for which means of control are recognized, but occasionally they present subjects that cannot be disposed of offhand. Notably two problems of the latter type, suggested by correspondents, have been added to our program this year. One has to do with the "Gymnosporangium" diseases of Red Cedars, ornamental Apples, Hawthorns, etc., and the other with elm diseases. Grateful acknowledgment is made of material assistance afforded by Dr. and Mrs. Henry Lyman and Mrs. Harold Irving Pratt, respectively, towards the investigation of these problems.

Our investigative undertakings have in part found expression in publication (11 titles); others have not yet reached that stage. Important among the former is a study of the "needle cast" fungi of Conifers by Dr. G. D. Darker; the results, presented in the form

of a handsomely illustrated monograph, have been issued as No. 1 of "Contributions from the Arnold Arboretum of Harvard University." Twenty-four species are described as new, 10 on Firs, 3 on Spruces, and 11 on Pines; also the pathogenicity of 5 species, of a limited number tested, has been established by direct experimentation. Distinct progress has been made on the beech disease problem in which the sequent agencies of an insect and a fungus are involved (John Ehrlich: The Occurrence in the United States of *Cryptococcus Fagi* Dougl., the Insect Factor in a Menacing Disease of Beech. Journ. Arnold Arb. 13: 75–80. 1931). Successful control measures have been tested through the coöperation of the Boston Parks Department. Also field work in the Maritime Provinces, where the trouble has been devastating, is now in course of completion, an undertaking made possible through a liberal grant made by the National Research Council of Canada. Quoting Mr. Richard J. Hayden, Superintendent of Parks, Boston, Mass. from a recent article in Horticulture—"This insect (factor) is new and has not had time to become widespread here. Hence its early eradication may prevent the establishment of a very serious pest." Mention also should be made of the completion of Dr. K. S. Chester's studies on Phytophthora Blight of Lilacs, and of his rectification of an error in the technique, fundamentally important, used by certain investigators in the uncharted domain of plant immunology as a means of recognizing acquired immunity in plants. Dr. Chester will continue his studies during 1932–3 in Europe.

A list of other topics under investigation includes: rusts of Conifers; trunk diseases of Conifers; wilt diseases of Elms; spermogonia of rusts (L. M. Hunter); "cedar apple" diseases of Red Cedar, Apples, Hawthorns, etc. (I. H. Crowell and J. D. MacLachlan); mycorrhiza of trees (A. B. Hatch; Mr. Hatch's present field work in the Black Rock Forest, New York State, is fully supported by a contribution from an unnamed donor through the Director of the Harvard Forest).—J. H. F.

Cytology Laboratory.—During the past year additional cytological studies have been continued to determine the relation between chromosome numbers and taxonomic grouping in different species and genera of woody plants. The plants investigated include species and genera in the Ulmaceae, Tiliaceae, and Cornaceae, as well as a number of rare or monotypic genera. A study of chromosome behavior in several genera of conifers by Mrs. Sax has provided information which may account for the morphological stability of this group of plants. A comparison of the chromosomes of *Yucca and Agave*, in collaboration with Mrs. McKelvey, proves

that these genera are closely related, even though they have been placed in different families by most taxonomists.

Cytological investigations of hybrids have thrown some light on the relationships of geographically distinct species, and have indicated the probable origin of the Pomoideae.

Several studies on the mechanism of chromosome pairing and division have been completed during the year. This work is a part of a general project involving an extensive study of the mechanism of heredity. Collaborators in this work include Dr. Anderson, Dr. Hally J. Sax, Mr. Dermen, Mr. King, and Mr. O'Mara.

During the past season more than 350 crosses have been made between different species and varieties of trees and shrubs. Relatively few crosses between distinct species are successful, but the species hybrids obtained should be of considerable interest. The breeding work has resulted in species hybrids of *Syringa*, *Lilium*, *Malus*, *Philadelphus*, *Ulmus*, *Lonicera*, *Ribes*, and *Rosa*. Numerous crosses were made between *Rosa rugosa* and other species, many of which were successful. This work was aided by a special contribution from a friend of the Arboretum.—K. S.

The Herbarium.—The Herbarium contains 358503 specimens, 10022 having been added between July 1, 1931 and June 30, 1932. Of the accessions approximately 2750 came from the United States and Canada, 1670 from Central and South America inclusive of Mexico, 390 from Europe and Western and Central Asia, 1400 from Eastern Asia and 375 from Southern Asia and Malaysia, 260 from Africa, 1250 from Australasia and 1200 represented cultivated plants.

Among the more important collections received during the year are the following: more than 1000 numbers with many duplicates collected by S. F. Kajewski in the Solomon Islands and about 250 collected by him in North Queensland, 400 specimens of Tasmanian plants purchased from the Tasmanian Museum, 750 Chinese plants collected in Kweichou by Y. Tsiang and 425 Chinese Plants collected in western China by J. F. Rock, 400 plants from northern Burma collected by F. Kingdon Ward, 600 numbers with duplicates collected in Sumatra by W. N. and C. M. Bangham, 160 Philippine plants collected by C. A. Wenzel, 260 Central African plants collected by J. Burtt Davy, 250 East African plants collected by H. Humbert, about 350 plants collected by G. Klug in Colombia (Putumayo River), 200 Brazilian plants from F. C. Hoehne, 520 Mexican plants from Stanford University, 220 numbers of Cuban plants with duplicates collected by J. G. Jack, and about 350 numbers of Yuccas with many duplicates collected by Mrs.

S. D. McKelvey, and with flowers and fruits in formaldehyde, cytological material, also insects pollinating the Yucca flowers.

The fruit collection numbers now 7439 specimens, 188 having been added during the year.

To the wood collection 83 specimens were added bringing the number up to 2365.

The collection of negatives of types and of other herbarium specimens consists now of 1857 negatives, 91 having been added during the year.

The installation of 16 new cases and 29 half-cases necessitated a rearrangement of the whole herbarium leaving space for accessions for a number of years. Besides constantly using the herbarium in the determination of plants sent in for identification and of some large collections chiefly from Eastern Asia and North America members of the staff have been engaged in special work; Dr. C. E. Kobuski has finished a revision of the Chinese species of *Jasminum* and Dr. Eva M. F. Roush is engaged in a similar revision of the genus *Eurya*, Dr. I. M. Johnston is continuing his work on the Boraginaceae, Mr. E. J. Palmer on the genus *Crataegus* and *Mr. A.* Rehder is continuing the revision of the ligneous plants described by H. Léveillé from Eastern Asia and the identification of collections of Chinese plants. Among visitors who have consulted the herbarium may be mentioned Dr. F. P. Metcalf of Lingnan University, Canton, China, Dr. E. D. Merrill of the New York Botanical Garden, Dr. S. F. Blake of the Department of Agriculture and Dr. R. E. Woodson of the Missouri Botanical Garden.

For study outside the Arboretum 931 specimens were sent on loan to institutions and individuals in this country and in Europe.

There have been distributed 22037 specimens to 40 institutions in the United States, Canada, Europe, Asia, Africa and Australia.

Botanical exploration by members of the staff or by expeditions partly financed by the Arnold Arboretum has been carried on in both Americas, Eastern Asia and Australia.

Mrs. Susan Delano McKelvey travelled from the middle of March to the end of May about 11000 miles in Texas, New Mexico, Arizona, California and Oklahoma for the purpose of studying and collecting *Yucca;* she obtained in addition to 350 herbarium specimens and 250 specimens of flowers and fruits in formaldehyde solution, about 100 numbers of chromosome material and 50 numbers of pollen smears, 125 numbers of entomological specimens including nearly 2000 Yucca moths and 100 excellent photographs.

Professor J. G. Jack spent the month of August 1931 and the months of February and March 1932 at the Harvard Tropical

Garden at Soledad, Cuba, and collected in the Garden and in the surrounding country about 4500 sheets of herbarium material besides wood specimens and seeds.

Mr. E. J. Palmer with Dr. Edgar Anderson collected during the month of April 1932 in the Atlantic coast region from New Jersey to Georgia, Mr. Palmer paying special attention to *Crataegus*.

Dr. H. M. Raup and Mr. E. C. Abbe started in June 1932 on a tour of botanical exploration of the Peace River region in the provinces of Alberta and British Columbia.

From March 1930 to May 1932 Mr. S. F. Kajewski has made extensive collections in the Solomon Islands and has collected more than 1000 numbers with numerous duplicates. Professor Albert N. Steward and Professor C. Y. Chiao of the University of Nanking undertook an expedition to the province of Kweichou from the end of June to November 1931 which proved very successful; an expedition to Kwangsi planned for 1932 had to be abandoned on account of the Sino-Japanese conflict in the spring of this year; it will probably take place next year. Professor H. H. Hu of the Fan Memorial Institute of Biology in Peiping sent his collector, Mr. F. T. Wang, to Szechuan during the summer of 1931 but owing to troubled conditions in that province the expedition was not quite as successful as was expected, though about 1000 numbers with duplicates were collected; this year the botanical exploration of Szechuan will be continued and probably extended into Yunnan. Mr. R. Goerz returned in August 1931 from his collecting tour into northeastern Asia Minor. G. Looser, a resident of Santiago, Chile, made a collecting tour in December 1931 to southern Coquimbo which is botanically almost unexplored.—A. R.

The Library.—Additions to the Library during the past year include 878 volumes, 205 pamphlets and 321 photographs, making a total of 40,648 bound volumes, 9,885 pamphlets and 16,786 photographs. Among the photographs are nearly 200 taken in the Arboretum during the spring and summer of 1931 by Mr. Herbert W. Gleason, about 100 taken by Mr. E. J. Palmer in the South and Middle West, 7 of the Bird Sanctuary at Lake Wales, Florida, including a large colored print of the Bok Singing Tower, the gift of Mrs. Edward Bok, 4 of Chinsegut Hill, Brooksville, Florida, the gift of Colonel and Mrs. Raymond Robins, and 80 post cards of "British trees published by the British Museum (Natural History)." To our collection of original drawings and water colors have been added by gift a beautiful water color of *Dendrobium Wardianum* by Mrs. Oakes Ames and an *Echeveria* by Miss M. A. Eaton, and by purchase 58 sheets of water color drawings recording with delicate

accuracy the many varieties of color and shading in Azaleas and Rhododendrons, by Mr. C. H. L. Gebfert.

Cards filed during the year include 1,200 in the Catalogue of books in the Library, 350 in the Catalogue of photographs, 5,446 in the "Card-index of New Genera, Species and Varieties published by the Gray Herbarium," and 3,827 in the manuscript "Index of Illustrations and of New Genera, Species and Varieties of Ligneous Plants published since 1915" prepared at the Arboretum.

In addition to the cards filed nearly 4,000 slips have been prepared and filed for the printed "Catalogue of the Library," which is now making satisfactory progress after a long delay due to unforseen circumstances.

Five hundred and seventy volumes, including periodicals, have been bound, while about 100 smaller books and pamphlets have been put into pamphlet binders.

The growth of the library and the increase in the number of persons using it have made necessary a large undertaking considered in former years unnecessary and disfiguring—placing book numbers on the back of the bindings. Much of this work has been done during the past year and has proved a great saving of time and effort as well as a means of locating books out of place, misplaced books being inevitable with shelves open to staff and visitors.

During the year a number of research workers have made use of the unusual facilities which the library affords, especially in Chinese literature. Dr. Franklin P. Metcalf of Lingnan University, Canton, China, left about the middle of September after nearly two years' study in the library and herbarium, preparing a Flora of Fukien. Dr. S. F. Blake of the United States Department of Agriculture spent some days examining the books on the floras of the world. Among other visitors using the library were Mr. Ahmed Hilmy, under the auspices of the Egyptian Legation, research workers from Arthur D. Little, Inc., and the United Fruit Company.

The number of new periodicals received during the year is rather larger than usual, many coming in exchange for the "Journal of the Arnold Arboretum," the "Arnold Arboretum Bulletin of Miscellaneous Information," "Contributions from the Arnold Arboretum of Harvard University," and for herbarium specimens, some by gift and a number by purchase. They are:

ACTA phaenologica. Deel i, afl. 1 → 's-Gravenhage. 1931 →

ACTA phytogeographica suecica. 1 → Uppsala. 1929 →

ACTA phytotaxonomica et geobotanica. Vol. i, no. 1 → Kyoto. 1932 →

ANNALES sabarienses: folia musealia. i. Szombathely. 1932.

Archivos de botanica do estado de S. Paulo. Vol. i, fasc. 1 → São Paulo. 1925 →

Auckland institute and museum. Records. Vol. i, no. 2. [Auckland.] 1931.

Black Rock forest. Bulletin. No. 1 → Cornwall-on-the-Hudson. 1930 →

Buenos Aires—*Universidad.* Revista de la Facultad de agronomía y veterinaria. Tomo vii, entrega 1 → Buenos Aires. 1930 →

Butantan, *Brazil—Instituto soroterapico.* Anexos das Memórias do Instituto de Butantan, Secção de botanica. Vol. i, fasc. 1–6. São Paulo. 1921–22.

Cavanillesia. Vol. i, fasc. 1 → Barcinone. 1928 →

Cracow, *Poland—Universytet jagiellonski.* Publicationes Instituti botanici. Nr. 1–8. Cracovie, *etc.* 1931.

Difesa delle piante contro le malattie ed i parassiti. Anno ix, n. 1–3. Torino. 1932.

Grand Canyon nature notes. Vol. v, no. 6, 8–10, 12; vi, 1 → [Grand Canyon.] 1931–32 →

Harvard university—*Botanical museum.* Botanical museum leaflets. No. 1 → Cambridge. 1932 →

Hong Kong naturalist. Vol. i, no. 1 → Hong Kong. 1930 →

Leaflets of western botany. Vol. i, no. 1 → San Francisco. 1932 →

Lyons—*Société botanique.* Nouveau bulletin. Année i, no. 1–4. Lyon. 1913.

Mesa Verde notes. Vol. ii, no. 1 → [Mancos, Colo. 1931] →

Nature. Vol. 129, no. 3244 → London. 1932 →

Physis. Tomo i → Buenos Aires. 1912 →

Sociedade broteriana. Memorias. Vol. i → Coimbra. 1930 →

Società internazionale di microbiologia—*Sezione italiana, Milan.* Bollettino. Vol. iv, fasc. 1 → Milan. [1932] →

South Africa—*Botanical survey.* Memoir 1 → Pretoria. 1919 →

Suigen, *Korea—Agricultural and forestry college.* Bulletin. No. 1–3. Suigen. 1925–28.

Symbolae botanicae upsalienses. i → Uppsala. [1932] →

Taihoku imperial university—*Herbarium.* Contributions. No. 1 → [Taihoku] 1930 →

Utrecht—*Rijks universiteit—Botanisch museum en herbarium.* Mededeelingen. No. 1 → Amsterdam. 1932 →

Among other important accessions are:

Kniphof, J. H. Botanica in originali. 12 cent. (in 6 vol.). Halae Magdeburgicae. 1758['57]–64. 1200 hand-colored plates.

GRABOWSKI, H. E. Flora von Ober-Schlesien. Breslau. 1843.

[RIOCREUX, Alfred. Collection of 87 original drawings. 1860.]—Beautifully tooled green leather binding. Purchased from the income of the Mary Robeson Sargent fund.

THUNBERG, C. P. Nova genera plantarum. Upsaliae. [1781–1801.]

HU, H. H. Enumeration of plants in Chekiang. [Peiping. 1930?]—Gift of the author.

LEUDERS, P. E. Etwas vom coffee. [Glucksburg. 1784.]

VALLET, Pierre. Le jardin du roy tres chrestien Henry IV roy de France et de Navare. [Paris.] 1608. 73 plates before numbers.—Unbound, in half green morocco book-box.

AMMANN, Paul. Character plantarum naturalis, à fine ultimo videlicet fructificatione desumtus, ac præmisso fundamento methodi genuinæ cognoscendi plantas, per canones et exempla digestus. Francofurti; Lipsiæ, apud Nicol. Scipionem. 1685.

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Ohio State University, Laselle Seminary, Smith College, Olmsted Brothers, University of New Hampshire, Massachusetts Agricultural College, Canada Department of Mines, Harvard Museum of Comparative Zoology and other institutions. Sixty seven photographs were loaned to the Royal Horticultural Society for the Conifer conference of 1931. A few books were borrowed.

The library has been fortunate in being able to make up from odd numbers and oversheets, with the aid of a few photostatic reproductions, several copies of the "Silva of North America" by C. S. Sargent. With the exception of one copy these have been sold. At the same time several complete sets of the plates were made in Paris, and may be purchased from the library. They would make a valuable addition to any botanical library or herbarium.

The library has also sold 1,972 photographs taken by the late Dr. E. H. Wilson in China, Japan, Australasia, India and Africa, and many other photographs.—E. M. T.

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Staff of the Arnold Arboretum, 1932-33

Oakes Ames, A.M., Arnold Professor of Botany, Supervisor.
John George Jack, Assistant Professor of Dendrology.
Alfred Rehder, A.M., Curator of the Herbarium.
Joseph H. Faull, Ph.D., Professor of Forest Pathology.
Irving Widmer Bailey, S.D., Professor of Plant Anatomy.
Karl Sax, Ph.D., Associate Professor of Cytology.
Edgar Anderson, S.D., Associate.
Ivan Murray Johnston, Ph.D., Research Associate.
Clarence E. Kobuski, Ph.D., Assistant Curator, Herbarium.
Ernest J. Palmer, Collector and Research Assistant.
Eva M. Fling Reddan, Ph.D., Assistant in the Herbarium.
Kenneth S. Chester, Ph.D., Research Assistant, Phytopathology.
Grant D. Darker, Ph.D., Assistant in Phytopathology.
Haig Demerjian, M.S., Research Assistant.
Ivan H. Crowell, A.M., Assistant in Phytopathology.
Hugh M. Raup, Ph.D., Research Assistant.
Ethelyn Maria Tinkham, Librarian.
Susan Delano McKelvey, A.B., Research Assistant.
Ethel Antoinette Andromedon, Business Secretary.
Katharine Eleanor Kelley, Assistant in the Library.
Louis Victor Schmitt, Superintendent.
William Henry Judd, Propagator.

ERRATA AND ADDENDA

Page 31, line 22 *for* relict *read* relic

" " line 18 from below *for* relicts *read* relics

" 75, line 8 *for* Sporadically *read* Sporadical

" 83, line 3 from below *for* **Hedycarya** *read* **Hedycaria**

" 112, line 2 from below *for* CHAMBEYRENIA *read* CHAMBEYRONIA

" 156, line 17 insert under **Jasminum lanceolarium** Roxb.:

Fagara volubilis E. Pritzel in Bot. Jahrb. XXIX. 422 (1900).—**Syn. nov.**

Zanthoxylum volubilis (Pritz.) Chung in Mem, Sci. Soc. China, I. 124 (1924).—**Syn. nov.**

S z e c h u a n: Nanchuan, Kinshan, *Bock & Rosthorn*, no. 19, July 1891 (Herb. Oslo and Berlin; photo. in A. A.).[1]

" 157, line 1 *for* 6954 *read* 6964

" 158, after line 11 from below insert under **Jasminum lanceolarium** var. **puberulum:**

Fagara volubilis E. Pritzel var. *pubescens* Pampanini in Nuov. Giorn. Bot. Ital. n. s. XVII. 406 (1910).—**Syn. nov.**

H u p e h: Monte "Triora," alt. 1950 m., *C. Silvestri*, nos. 1221 and 1221a, Sept. 1907 (Herb. Biondi, Florence; photo. in A. A.).

" 195, line 10 from below *for* In *read* If

" 302, line 6 *for* 1928 *read* 1898

" 329, line 5 from below *for* 1351 *read* 1531

[1] When examining recently the types of Pampanini's new species and varieties of Chinese plants in the Erbario Biondi at Florence, I found that the plant described as *Fagara volubilis* var. *pubescens* and represented by a fruiting specimen belongs to *Jasminum lanceolarium* Roxb. var. *puberulum* Hemsl. This led me to examine typical *Fagara volubilis* E. Pritz. of which there is in the Arnold Arboretum herbarium a photograph of the type specimen, taken by me in the herbarium of the Botanic Garden in Oslo. The photograph shows clearly that this plant too is not a *Fagara*, but is identical with *Jasminum lanceolarium* Roxb. which was collected later in the same locality by W. P. Fang. Also Pritzel's description fits *Jasminum lanceolarium*. Therefore, both *Fagara volubilis* E. Pritz. and *Fagara volubilis* var. *pubescens* Pampan. become synonyms of *Jasminum lanceolarium* Roxb. and its variety.—A. Rehder.

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